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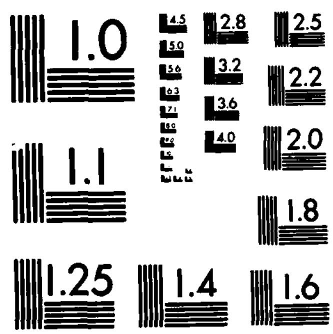

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STUDY REPORT
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ECONOMETRIC MODEL FOR OPTIMIZING TROOP DINING FACILITY OPERATIONS (THE ARMY MASTER MENU STUDY)

NOVEMBER 1982

PREPARED BY

ANALYSIS SUPPORT DIRECTORATE

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18. SUPPLEMENTARY NOTES
Portions of this study are intended to address concepts involved in mobilization. Mobilization is Priority Problem Area (PPA) #6 under the current Army Study Program (TASP).

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
(U) Active Army; (U) Logistics; (U) Planning; (U) Model Development; (U) Menu Planning; (U) Goal Programing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The Econometric Model for Optimizing Troop Dining Facility Operations, also referred to as the Army Master Menu Study, consists of the development of the methodology and associated model which may be used to analytically guide the preparation of the Army Master Menu. The methodology is centered around a goal programing model in which the achievement of goals for acceptability, food cost, labor cost, and nutritional adequacy may be selectively prioritized by the menu planner. The menu planning model consists of three distinct modules: The Data
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20. Continued.

Handling Module, The Parameterization Module, and the Solution Module. The Data Handling Module provides for the maintenance of data concerning recipe attributes and menu components in an interactive, user friendly environment. A preprocessor incorporates a consistent analytical approach to the evaluation of menus in terms of cost, labor, nutrition and acceptability. The Parameterization Module provides the menu planner with the capability to establish menu planning goals, reorder priorities, and impose constraints in the development of alternative menu plans. A matrix generator incorporates the menu attributes and planning parameters into a complete mathematical model. The Solution Module consists of a highly efficient sequential linear goal programing (SLGP) algorithm that was developed specifically for this study. The SLGP algorithm employs the XMP library of subroutines for experimental math programing. A report generator displays the completed menu plan in a series of reports that indicate the menus and recipes selected for inclusion in the menu plan, an assessment of goal deviation and a summary of menu attributes. The menu planning model provides the menu planners at the Troop Support Agency, Ft Lee, VA with a design tool capable of rapidly and accurately responding to changes in costs, preference patterns and nutritional requirements in the design and evaluation of alternative menu plans.

STUDY REPORT
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ECONOMETRIC MODEL FOR OPTIMIZING TROOP DINING FACILITY OPERATIONS

(THE ARMY MASTER MENU STUDY)

NOVEMBER 1982

Prepared by

Analysis Support Directorate

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DEPARTMENT OF THE ARMY
US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20014

REPLY TO
ATTENTION OF

CSCA-ASA 15 November 1982

SUBJECT: Econometric Model for Optimizing Troop Dining Facility Operations

Deputy Chief of Staff
for Logistics
Department of the Army
ATTN: DALO-TST
Washington, DC 20310

1. Reference is made to letter, DALO-TST, 28 December 1981, subject as above, which tasked CAA to develop a methodology and associated models that could be used to guide the analytical preparation of the Army Master Menu.

2. Attached is the final report which documents the development of a methodology that fulfills the above directive. The study report describes an integrated methodology which will be capable of prioritizing the achievement of goals for raw food cost, labor cost, acceptability, and nutritional adequacy in the design of the Army Master Menu. The associated menu planning model has been placed into operation on the computer system at Ft Lee, VA, which is shared by the US Army Troop Support Agency.

3. Recommendations concerning the validation and implementation of the methodology and associated model are contained in Chapter 7 of the study report. In keeping with these recommendations, it is anticipated that the model's capabilities may best be realized if preceded by a period of time during which experience is gained concerning the use of the model. Although the official period of CAA involvement is over, this Agency will continue to be interested in your assessment of the model as it is implemented in the menu planning process.

4. Your written evaluation of the study results, as required by paragraph 3-5.a, AR 5-5, will assist this Agency in maintaining quality analytical support.

David C Hardison

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as

DAVID C. HARDISON
Director

SUMMARY

1. STUDY PURPOSE. While the title of this study is the Econometric Model for Optimizing Troop Dining Facility Operations, the purpose of the study is to develop the methodology and associated models which may be used to guide the analytic preparation of the Army Master Menu. For that reason, the study may be referred to by its short title, The Army Master Menu Study.

2. BACKGROUND

a. The Army Master Menu. The Army Master Menu is an integral part of the Army food program and is essentially a list of "what is to be made." The Master Menu is currently published on a monthly basis and is used as a guide in the planning of meal selections. In 1972, the Army Ration Credit System (ARCS) was implemented, and under this system, the food service sergeant is given the latitude to requisition subsistence on a line item basis. He may follow the Master Menu or make whatever deviations are necessary to satisfy the eating habits and desires of the troops eating in his dining facility. However, the food service sergeant must keep his food costs within a 3 percent tolerance of a monthly allowance which is based on the basic daily food allowance (BDFA) and the number of diners being served. The Master Menu is important as a guide because, although deviations are allowed, the food service sergeant must rely on the Master Menu to provide for nutritional adequacy, general acceptability, and relative cost efficiency. Currently, the Master Menu is based on a 42-day menu cycle and reflects an effort to balance the factors of cost, nutrition, and acceptability.

b. Computerized Menu Planning. The first automated approaches to menu planning were made in the 1940s, and the problem of finding a nutritionally adequate diet at the least cost (the diet problem) is a classic example of the application of linear programing (LP) methods. In fact, LP solutions to the diet problem have been very successful in formulating various feed blends for animals. The problem of developing menus for human consumption is another matter. Early models typically took the approach of attempting to optimize a single factor such as minimizing cost, subject to nutritional requirements and other constraints. Even later models which incorporated acceptability by establishing minimum time intervals between successive servings of the same menu item did not get much beyond the stage of being curios. There has been some significant work done in the area of computerized menu planning within the last several years. Some very sophisticated methods involving the use of nonlinear preference functions are currently being used at the US Army Natick Labs. These models do not take labor cost into consideration, nor do they consider more than one factor in the optimization process. The advent of goal programing provides an answer to some of these problems in that several objectives may be considered and ordered in preemptive priorities. Therefore, nutrition, food cost,

acceptability, and labor cost may all be considered in achieving the menu which comes as "close as possible" to the satisfaction of all these factors.

3. THE PROBLEM. The current method of developing the Master Menu is a subjective technique using manual and partially automated procedures. There is no consistent analytical approach to providing the best menu in terms of food cost, acceptability, or nutritional adequacy. In addition, no consideration is given to the relative labor costs involved in preparing the menu. While the role of the dietician and nutritionist is not to be minimized, there is significant need for an efficient planning tool that is capable of rapidly and accurately responding to changes in cost, nutritional requirements, and preference patterns. Existing procedures are considered to be inadequate for a program which not only comprises a major portion of the subsistence budget, but also is a prime factor in maintaining the health and morale of the individual soldier. At the current time, the process is essentially a manual one. Computers are used for data retrieval purposes, but otherwise the menu planner employs a combination of heuristics and experience to plan the menu over an entire year. An outline of the process currently employed at the US Army Troop Support Agency (TSA) is shown in Figure 1.

4. OBJECTIVES. The objectives of the study are as follows:

a. Identify the menu planning parameters, to include:

(1) The collection and analysis of data for the recipies and selected menus that are to be included in the study.

(2) The identification of appropriate goals for food cost, labor cost, acceptability, and nutritional value.

b. Develop a methodology which is capable of selectively achieving the above goals in the design of the Army Master Menu.

c. Apply the methodology to the design of a sample 42-day Master Menu based on serving 100 individuals in accordance with the policies and procedures of ARCS.

5. METHODOLOGY

a. Goal Programing (GP). The selection of an analytic methodology was based on the need to select the best combination of menus in terms of the four objectives shown in Figure 2. GP is a tool that allows for the incorporation of multiple objectives into the mathematical optimization process and was therefore the basis of the menu planning model. The GP methodology is based on an attempt to achieve each objective in a preemptive fashion. Prioritizing the goals implies that one is preferred to another, which is preferred to another, etc.; while preemptive prioritization implies that one is preemptively, or infinitely, preferred to another.

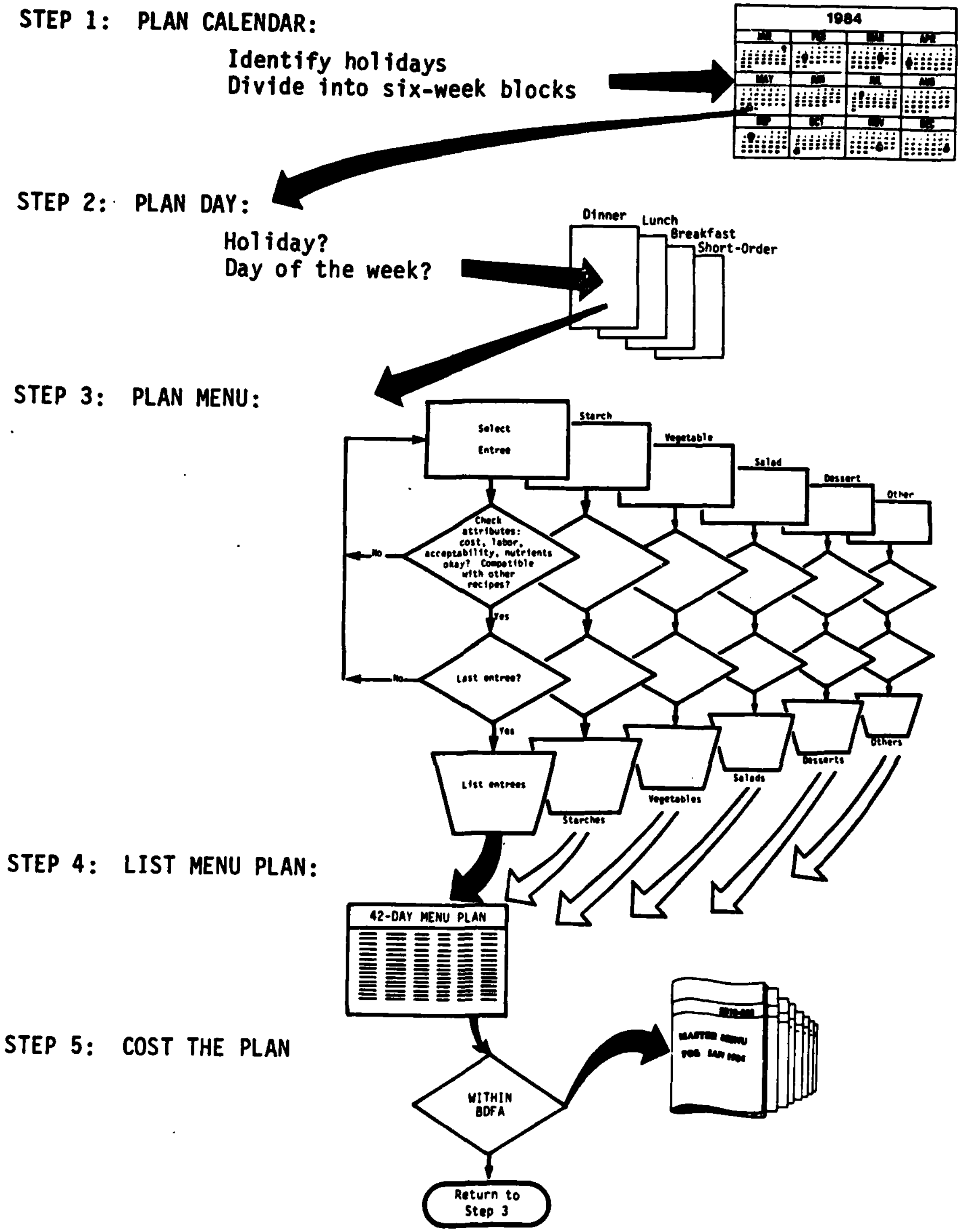

Figure 1. TSA Menu Planning Process

Figure 2. The Army Master Menu Objectives

b. Menu Attributes. The relative worth of menus is measured in terms of attributes for food cost, labor cost, acceptability, and nutritional content. The study methodology incorporates a procedure for assessing the worth of menus in terms of these four attributes. The procedure involves the determination of the menu attributes based on appropriate linear combinations of the attributes for those recipes comprising each menu. This procedure allows for the consistent analytic determination of menu attributes which are subsequently used as input to the GP algorithm.

6. SYSTEM DESIGN. A graphical representation of the model structure is shown in Figure 3. The structure corresponds to the logical sequence of operations in menu planning. The user is able to interface with recipe and menu data files in order to maintain and update that data. The preprocessor has the function of generating the menu attribute file, and once the menu attribute file has been created, a set of rigid constraints is implicitly incorporated into the generation of the goal programing problem matrix. A set of upper bounds is initially placed on all menus to preclude excessive repetition; however, the user may alter these bounds either to require the inclusion of menus at a certain level of frequency, or to restrict other menus from being selected. The user may also select the menu planning goals and priority order. Once the problem matrix has been generated and menu planning parameters such as bounds, goals, and priorities have been established, the solution may be generated through use of the GP solution algorithm. Solutions are displayed in the five reports shown at the bottom of the figure.

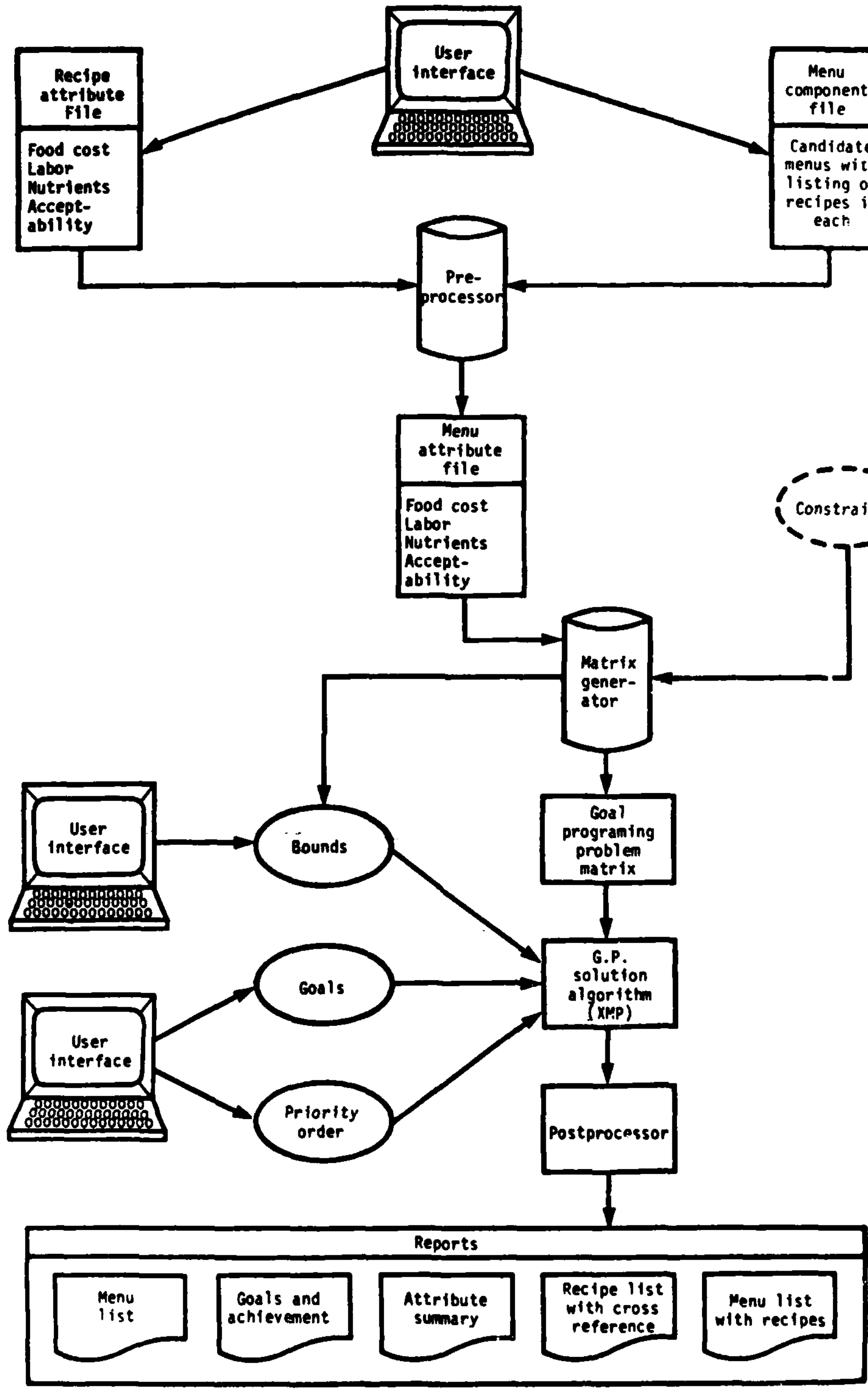

Figure 3. Model Structure

7. ESSENTIAL ELEMENTS OF ANALYSIS (EEA). The EEA that guided the conduct of the study are summarized below.

a. Does the methodology provide a product which is useful in the design of the Master Menu? Yes. The design was based on considerations imposed by the current menu planning process. The emphasis in model design was on flexibility, ease of operation, accuracy, and reliability. The concept of integrating the model into the existing system was considered so that the menu planners would find the model useful for maintenance of data, assessment of the relative worth of menus, and development of complete menu plans.

b. Does the model provide a useful tool for obtaining insights into food service resource allocation in consideration of changes in priorities, resource costs, preference patterns, and nutritional requirements? Yes. The ability to reorder priorities and rapidly rerun the model has made the identification of resource tradeoffs a simple process. As can be seen in Figure 3. the menu planner is able to interface with the model at several points in the menu planning process. As a result, changes to recipe attributes, composition of menus, order of priorities, and goals may be made quickly and easily. The effect of these changes may be assessed within the context of the series of solution reports.

c. Is the methodology appropriate for future applications to mobilization conditions? Yes. The current DA Master Menu will serve as the basis for mobilization menu development since it will be readily available. It is expected that the locally developed mobilization menu will normally be more austere than that which is currently served during peacetime, e.g., multiple entrees and wide choices of vegetables and desserts will not be offered. While the emphasis on providing wholesome, nutritious food in adequate portions will continue, additional emphasis is to be placed on the reduction of manpower requirements. A specially designed data set of less labor intensive menus can be developed and loaded into the model whenever mobilization menu planning is to be conducted. Specific guidance concerning special procedures to be employed in planning mobilization menus is contained in the study report.

d. Can the programs be made transportable for use on the computer system available to TSA? Yes. Portability was a prime consideration in the system design and the selection of an optimization algorithm. While some modifications were necessary due to different word lengths and intrinsic functions, a working model has been put into operation at FT Lee.

8. OBSERVATIONS. The following observations resulted from this study:

a. The use of this model in conjunction with a food service management information system (MIS) can significantly help the menu planning process at TSA.

b. The inclusion of labor costs in the menu planning process is highly appropriate; however, the validity of the labor data should be closely scrutinized.

c. Prioritizing the achievement of several menu planning goals is accurately reflected by the use of a GP algorithm.

d. While the model is a highly flexible menu planning tool, successful implementation will be enhanced by the development of a comprehensive plan for model validation, implementation, and training.

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ECONOMETRIC MODEL FOR OPTIMIZING TROOP DINING FACILITY OPERATIONS (THE ARMY MASTER MENU STUDY)

CHAPTER 1

INTRODUCTION

1-1. STUDY PURPOSE. The development of the Econometric Model for Optimizing Troop Dining Facility Operations resulted from concern that there were no consistent considerations of acceptability, resource cost, or nutritional adequacy in the design of the Army Master Menu. The purpose of this study is to develop the methodology and associated models which will be used to analytically guide the preparation of the Army Master Menu. The study may be referred to by its short title: The Army Master Menu Study.

1-2. BACKGROUND

a. This study was requested by the Deputy Chief of Staff for Logistics (DCSLOG) after correspondence relating to the problem had been received from the Troop Support Agency (TSA) at Fort Lee, VA. That correspondence cited the need to plan and execute the most efficient menu possible in consideration of rising food and labor costs. The original work unit summary on the subject envisioned the development of a model that was capable of analytically guiding the preparation of the Army Master Menu.

b. The US Army Concepts Analysis Agency (CAA) was officially directed to study the problem in a tasking directive from the DCSLOG dated 28 December 1981 (Appendix B). The study directive provided for the establishment of a study team that would "provide a design tool which can be utilized to guide the preparation of the Army Master Menu in garrison conditions and . . . provide a demonstration of application." A final report was required by 31 October 1982.

1-3. THE PROBLEM. The current method of developing the Master Menu is a subjective technique using manual and partially automated procedures. There is no consistent analytical approach to providing the best menu in terms of food cost, acceptability, or nutritional adequacy. In addition, no consideration is given to the relative labor costs involved in preparing the menu. While the role of the dietician and nutritionist is not to be minimized, there is significant need for an efficient planning tool that is capable of rapidly and accurately responding to changes in cost, nutritional requirements, and preference patterns. Existing procedures are considered to be inadequate for a program which not only comprises a major portion of the subsistence budget, but also is a prime factor in maintaining the health and morale of the individual soldier.

1-4. OBJECTIVES. The objectives of this study were to:

a. Identify the menu planning parameters, to include:

(1) The collection and analysis of data for the recipes and selected menus that are to be included in the study.

(2) The identification of appropriate goals for food cost, labor cost, acceptability, and nutritional value.

b. Develop a methodology which is capable of selectively achieving the above goals in the design of the Army Master Menu.

c. Apply the methodology to the design of a sample 42-day Master Menu based on serving 100 individuals in accordance with the policies and procedures of the Army Ration Credit System (ARCS).

1-5. SCOPE. This study is intended to provide a design tool which can be utilized to guide the preparation of the Army Master Menu in garrison conditions and to provide a demonstration of application.

1-6. LIMITATIONS. In order to narrow the range of subjects to be addressed in this study, the tasking directive imposed several limitations.

a. The problem of designing individual meals was not addressed.

b. The compatibility of two or more meals served on a given day was not addressed.

c. The requirements of short order and specialty dining facilities were not considered; however, the selection of short order meals in the overall menu plan was addressed.

d. No attempt was made to conduct either an analysis or an optimization of staffing, storage requirements, nor equipment utilization. The fact that no analysis of staffing was conducted means only that no attempt was made to distinguish between skill levels and pay grades; however, labor cost was considered and is identified as being the total number of manhours required to prepare a particular menu.

1-7. ASSUMPTIONS. The following major asssumptions were either established in the tasking directive or determined to be necessary during the course of the methodology development:

a. Data concerning recipe attributes for food cost, labor cost, nutritional content, and acceptability as provided by the TSA are admissible as input to this study.

b. Problem formulation as a linear, deterministic, mathematical model provides an adequate representation of the system under study.

c. Food cost and nutritional content are linear with respect to the amounts of food being served.

d. There is a fixed labor cost associated with the preparation of 100 or fewer servings of any recipe.

e. The acceptability of a recipe is independent of the other recipes on the menu.

f. The nutritional benefit of a recipe is proportional to the acceptability of that recipe. This assumption reflects the fact that since nutritional benefit is derived only from the food that is actually consumed, it must be assumed that the individual diners consume all that they select from the serving line.

1-8. ESSENTIAL ELEMENTS OF ANALYSIS (EEA). As stated in the study directive the EEA are:

a. Does the methodology provide a product which is useful in the design of the Master Menu?

b. Does the model provide a useful tool for obtaining insights into food service resource allocation in consideration of changes in priorities, resource cost, preference patterns, and nutritional requirements?

c. Is the methodology appropriate for future applications to mobilization conditions?

d. Can the programs be made transportable for use on computer systems which are available to TSA?

1-9. CONTENTS OF THE REPORT. The following chapters, supported by appendices, present the results of this study. Chapter 2 contains a discussion of menu planning, both in general and as currently applied by the Army. Chapter 3 discusses the study methodology, while Chapters 4 and 5 detail the design of the menu planning model and the mathematical programing algorithms that are involved in the optimization process. Chapter 6 presents an assessment of the degree to which the various study objectives have been met; and an analysis of the results of several sample menu plans. Chapter 7 extends this assessment of the model's capabilities into a discussion on the concept of operations for the menu planning model. This discussion includes recommendations concerning the integration of the model within the existing menu planning system and its interface with proposed management information systems. Chapter 8 completes the report with observations about the study and possible alternative approaches for future consideration. A users' manual for the menu planning model is published separately.

CHAPTER 2

MENU PLANNING

2-1. THE ART OF MENU PLANNING. In spite of increased knowledge in the areas of dietetics, nutrition, and preference patterns, menu planning remains primarily an art. It is an art that has been significantly enhanced by scientific knowledge, but it is still an art that a person learns through the application of heuristics and trial and error processes. It is clear that any menu planning system is doomed to failure if it does not build on the experience of the existing process. It is therefore necessary to explain the existing process and to explain a few terms before going on to the details of the study methodology.

2-2. EXPLANATION OF TERMS. There are several terms that will be used repeatedly and must be understood in some detail. An additional list of terms and their definitions may be found in the study glossary.

a. Recipe. A recipe is the end result of a process of food preparation, such as buttered peas, grilled hamburgers, etc. A recipe is distinguished from a food item such as the ground beef that is used in a hamburger recipe.

b. Menu. A menu is a listing of the recipes to be served for a given meal. The terms menu and meal are often used interchangeably, but reference to a meal usually implies a period of time during which a menu may be served. As an example, a menu consisting of fried eggs and french toast may be served appropriately during the breakfast meal only, while a menu consisting of a hot roast beef sandwich and mashed potatoes may be served during either the lunch or dinner meals. A menu is not to be confused with the master menu, which is a listing of all the individual menus that are to be served during a designated period of time. The distinction between an individual menu and the overall menu plan will be clear in the context of the discussion.

c. Master Menu. The Master Menu, as published monthly by Headquarters, Department of the Army, is developed by the Troop Support Agency (TSA). It is provided as a guide for use in Active Army dining facilities and includes breakfast, lunch, short order, and dinner menus for each day of the month.

d. Menu Cycle. A menu cycle is the specified period of time during which a series of menus is to be served. In theory, the same series of menus would then be repeated during the next cycle. In practice, price changes, feedback concerning the acceptability of menus, and other factors will influence the selection of menus that are to be served during subsequent menu cycles. The length of the menu cycle may vary. In a hospital where patients normally stay an average of 5 days, the cycle length may be 7 days. The length of the standard menu planning cycle used by the Army is 42 days.

e. Recipe and Menu Attributes. Recipe and menu attributes may be any identifiable characteristic of a recipe or menu. The main attributes considered in this study are food cost, labor cost, nutritional content, and acceptability.

(1) Food Cost. Food cost is the cost of a recipe or menu in terms of the cost of the raw foods constituting it.

(2) Labor Cost. Labor cost is the cost in terms of the number of manhours involved in preparing the recipes and menus.

(3) Nutritional Content. The nutritional content of a recipe or menu is in terms of those nutrients which are considered to be essential for a well-balanced diet.

(4) Acceptability. Acceptability is a measure of the acceptance of a recipe by how many people select that recipe when it is placed on the serving line. Menu acceptability will be explained in Chapter 3.

2-3. GENERAL CONSIDERATIONS. It is not the intent of this chapter to provide an exhaustive discussion of menu planning, but to supply some background information. A good reference for the individual who wants more information on menu planning is Menu Planning by Eleanor F. Eckstein, Ph.D. (AVI Publishing Co., 1978). Table 2-1 illustrates the complexity of information considered in the menu planning process. Not all of the considerations shown may be successfully addressed within reasonable time and cost limitations. However, failure to systematically evaluate the implications of the universal considerations results in many of the problems shown in Table 2-2.

Table 2-1. Universal Considerations[a]

- Knowledge of the people to be served: nutritional requirements, food habits, and the number of people per meal period.

- Conditions of preparation and service: availability of equipment and its arrangement in terms of efficiency; personnel--schedules, skills, and abilities; budget; style of service.

- Outside influences: season, climate, availability of foods.

- Food combinations: variety in texture, color, flavor, form or shape, consistency, temperature, satiety value, preparation method.

[a]Source: Menu Planning, Eleanor F. Eckstein, Ph.D., AVI Publishing Co., 1978.

Table 2-2. Universal Problems[a]

- Cultural and/or religious subgroup dissatisfaction with the selection offered.

- Worker dissatisfaction due to variable and/or excessive workload.

- Monotonous repetition of some items, although the recipe file contains numerous acceptable items.

- Pairs of alternate items that do not improve the choice (forced choice between two unacceptable items is common).

- Nutritional balance on paper which is achieved by including liver and/or other rich but unacceptable sources of critical nutrients.

- Combinations that are aesthetically poor.

[a]Source: Menu Planning, Eleanor F. Eckstein, Ph.D., AVI Publishing Co., 1978.

2-4. MECHANICS OF MENU PLANNING. Menu planning may be as detailed or as general as one likes, but in its simplest terms the process can be reduced to determining which recipes are to be served and how often they are to be served. The most basic element in the master menu is the food item. As illustrated in Figure 2-1, food items are combined to form recipes, recipes are combined to form menus, and menus are combined to form the overall menu plan. At each step, there are a number of factors that must be considered. The complexity of the task is increased as more factors are considered. The most complex process is the one of combining recipes into menus, since it is during this process that the greatest number of interacting factors must be considered. On the surface, this process appears to be one of answering a series of questions with a yes or no answer. A recipe is placed into consideration, and if it fails to meet any of the criteria for expense, labor intensity, time since last serving, etc., it is rejected. It must be remembered that the planning factors represent various objectives that the menu planner is attempting to achieve to a greater or lesser degree. Table 2-3 lists some typical planning factors with corresponding objectives. The process breaks down because the menu planner is able to consider only a limited number of objectives at one time. Some factors may be unintentionally ignored until they become critical, and when adjustments are made to increase the priority of those factors, other problems occur. This typically results in poor planning.

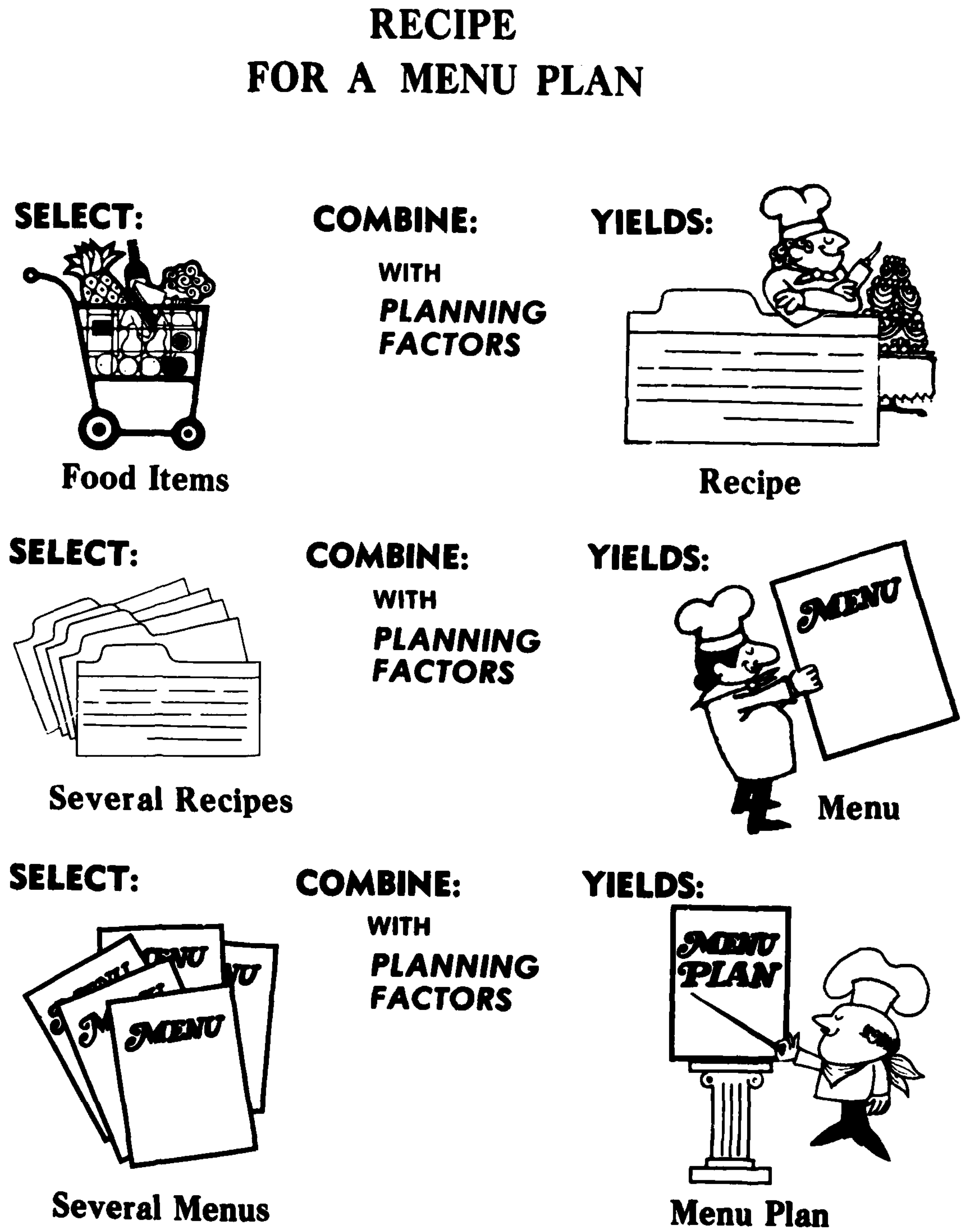


Figure 2-1. Recipe for a Menu Plan

Table 2-3. Menu Planning Factors

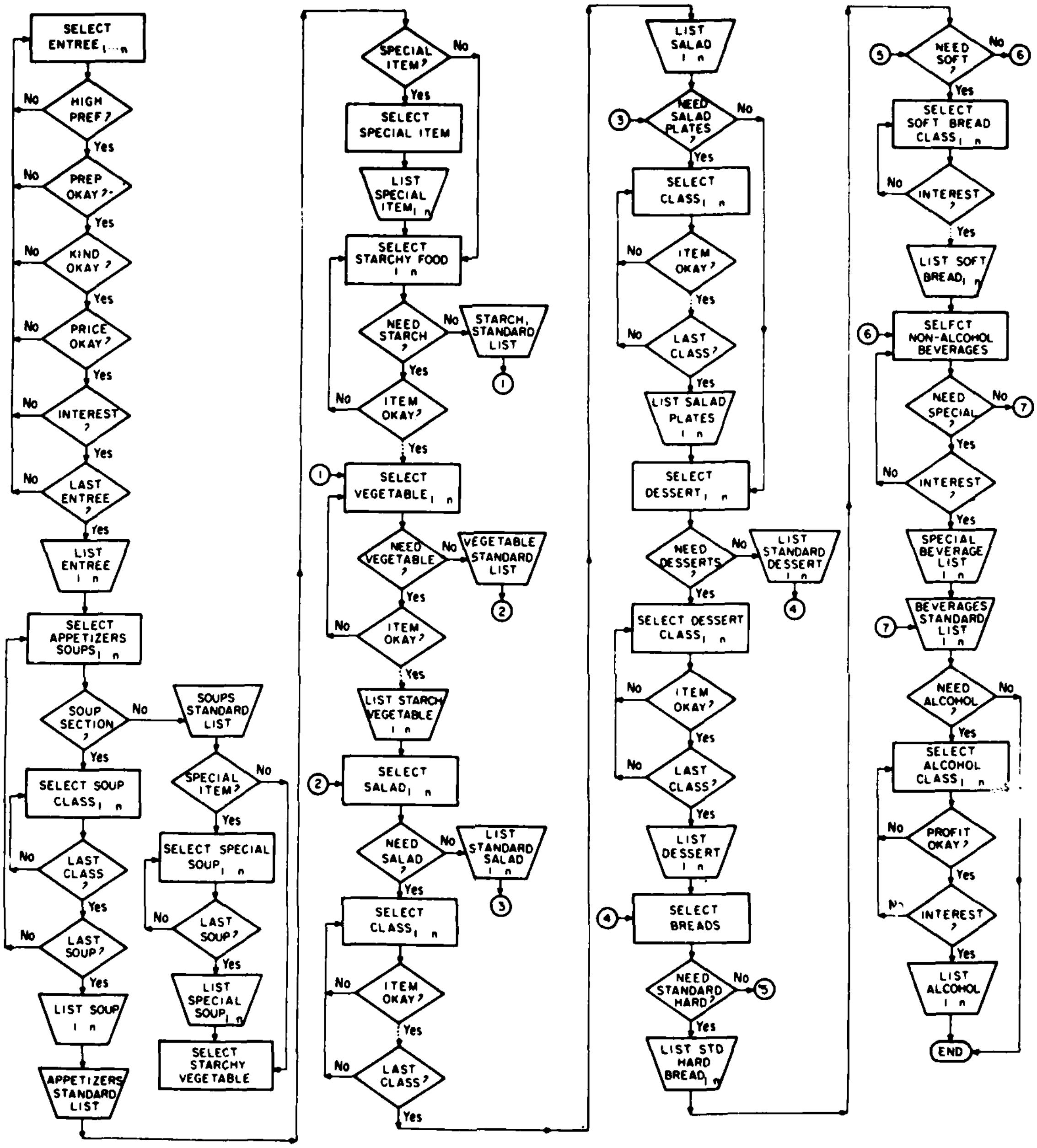
Planning Factor	Objective
Nutrition	Achieve the recommended dietary allowance for essential nutrients
Cost	Consistently remain within allocated subsistence funds
Acceptability	Maintain diner satisfaction
Variety	Avoid repetition
Color	Achieve visual harmony
Texture	Maintain variety of food textures

2-5. COMPUTER MENU PLANNING. The complexity of the menu planning process has led to an increased interest in the use of the computer for menu planning. Unfortunately, acceptance of computer menu planning has not been very widespread. There are several reasons for this, two of which are: (1) menu planning decisions are made in house without the influence of external competition; and (2) in-house content of menu choices is often jealously and zealously guarded. These are not the only reasons. The cost of training personnel and of providing sufficient data is purported to be prohibitive. On the other hand, the computer is consistent, logical, and, if used properly, may allow the menu planner to concentrate on those areas where experience and human judgment are irreplaceable. The fact that computer applications have not been widely accepted does not change the fact that the computer has proven to be a very useful tool. Computer applications in menu planning have centered on the areas of (a) data retrieval; (b) modeling; and (c) mathematical optimization.

a. Data Retrieval. Perhaps the greatest use of the computer in menu planning has been in the area of data retrieval. Since the computer can access external storage devices, it has a virtually unlimited capability for storing data. The advent of sophisticated database techniques has simplified the rapid retrieval and update of data. Supposedly, the job of the menu planner is simplified, or at least enhanced, because of the increased amounts of data that are available.

b. Modeling. The use of computer models to replicate the manual process has had wide application in menu planning. If a process can be completely defined in terms of quantitative data, then it can usually be modeled. Models may be tremendously complex and involve the design of many decision trees. A schematic of the process of item selection that may be used in a computer model is shown in Figure 2-2. The result may be a menu that is adequate without addressing the question of whether it is better or worse than some alternative.

c. Mathematical Optimization. The first automated approaches to menu planning were made in the 1940s and the problem of finding a nutritionally adequate diet at least cost (the diet problem), is a classic example of the application of linear programing (LP) methods. In fact, LP solutions to the diet problem have been very successful in formulating various feed blends for animals. The problem of designing menus for human consumption is another matter. The process involved in mathematical optimization involves the development of an objective function that will be maximized or minimized subject to a set of constraints. The popularity of mathematical programing techniques is largely a result of the availability of very efficient solution algorithms that are capable of solving problems involving thousands of variables and constraints. There are several areas of mathematical programing including linear, nonlinear, stochastic, and dynamic programing. All involve the optimization of a single factor subject to a set of rigid constraints. A relatively new field of mathematical optimization is multicriteria optimization. Multicriteria approaches attempt to achieve the best solution within a feasible region as defined by several criteria at once. These criteria or objectives may be weighted or prioritized according to the requirements of the situation. Prior to this study, little work had been done in the area of multicriteria menu planning.



Source: Menu Planning, Eleanor F. Eckstein, Ph.D.

Figure 2-2. Table Service Menu Planning Flow Chart for a la Carte Menus

2-6. THE ARMY MASTER MENU. The Army Master Menu is an integral part of the Army food program and is essentially a list of "what is to be made." The Master Menu is currently published on a monthly basis and is used as a guide in the planning of meal selections.

a. Responsibilities

(1) The Deputy Chief of Staff for Logistics (DCSLOG) has Army General Staff responsibility for managing the Army Food Service Program and as such develops plans, programs, policies, and doctrine that impact on the design of the Master Menu.

(2) The Surgeon General is responsible for establishing appropriate nutritional and dietary standards for personnel subsisted under normal and special operating conditions.

(3) The Commanding General, TSA, develops CONUS and overseas annual food plans, master menus, and special purpose menus.

b. Food Plan. The annual food plan is a consolidated listing of all subsistence items to be utilized for troop feeding requirements during a 12-month period. Factors considered in the development of the food plan are acceptability, availability, food cost, nutritional requirements, and a number of other factors. The food plan is determined primarily by the requirements of the Master Menu.

c. Menus

(1) The monthly Master Menu is provided as a guide for use in Active Army dining facilities. It includes a breakfast, lunch, dinner, and short order menu for each day of the month. While published in SB 10-260 on a monthly basis, the Master Menu is based on a 42-day menu cycle and is comprised of those recipes listed in TM 10-412 and additional recipes as determined by TSA.

(2) The 14-day US Army Reserve Component Menu (SB 10-263) is provided as a guide for Reserve Component personnel.

(3) Special menus are developed, upon request, by TSA to meet specific needs.

d. The Army Ration Credit System (ARCS). ARCS was implemented in 1972, and under this system, the food service sergeant is given the latitude to requisition subsistence on a line item basis. He may follow the Master Menu or make whatever deviations are necessary to satisfy the eating habits and desires of the troops eating in his dining facility. However, the food service sergeant must keep his food costs within a 3 percent tolerance of a monthly allowance which is based on the basic daily food allowance (BDFA) and the number of diners being served.

(1) Meal Service Schedule. Normally meals will be served during three meal periods each day. Local conditions may make the serving of two meals more advantageous than the normal three meals. The serving periods will be such that a diner may consume three meals if desired. Under this procedure the dining facility will earn credits based on three meals. For the purposes of this study, lunch and short order menus are considered to be served during the same meal period.

(2) Computation of Monetary Credits. Monetary credit is the dollar value earned by the dining facility for each authorized person subsisted. The supporting Troop Issue Subsistence Activity (TISA) will furnish each supported dining facility with the value of the BDFA at the beginning of the monthly accounting period. The BDFA is computed monthly by the Troop Issue Subsistence Officer (TISO) as prescribed by AR 30-18. An example of the monetary credit for a BDFA of $3.47 is shown in Table 2-4. An increase in the BDFA allowance is authorized under certain conditions, such as the serving of traditional holiday meals.

Table 2-4. Computation of the BDFA

Meal	Meal% factor	X	BDFA	=	Computed value	X	Actual head count	=	Monetary credit
Breakfast	20%	X	3.47	=	.69	X	110	=	75.90
Lunch	40%	X	3.47	=	1.39	X	150	=	208.50
Dinner	40%	X	3.47	=	1.39	X	165	=	229.35

(3) Forced Issues. As determined by the TISO and food advisor, it is sometimes necessary to force issue certain items in order to preclude a loss to the Government. Costs of subsistence for this type of issue will not be charged to the dining facility account but will be accounted for as prescribed in AR 30-1.

e. Special Considerations. There are a great many special factors that must be considered in the design of the Army Master Menu. The Army does not have an ethnically homogeneous population, and in recent years an emphasis has been placed on providing the soldier with multichoice, self-service menus. Recipes of an ethnic variety are being served with some frequency and yet the diner must be given choices so that the items served meet with the desires of a majority of regular diners. Nutritional requirements are somewhat special and are explained in Chapter 3 of this report.

f. Menu Planning. A compilation of Armed Forces menu standards is listed in Appendix D. These standards may vary somewhat, but it is standards such as these that guide the menu planners at TSA through the process of compiling the Army Master Menu. At the current time, the process is essentially a manual one. Computers are used for data retrieval purposes, but otherwise the menu planner employs a combination of heuristics and experience to plan the menu over an entire year. An outline of the process currently employed at TSA is shown in Figure 2-3.

(1) The Master Menu is initially planned 2 years in advance, and the first step in the planning process consists of laying out the calendar for the appropriate year. The calendar is divided into 6-week blocks and holidays are identified.

(2) Beginning with the first day of the first 6-week block, a daily menu plan is outlined, normally consisting of four menus: dinner, lunch, breakfast, and short order.

(3) Dinner is the first menu planned for each day. An entree is selected from a list of entrees served the previous year plus any new entrees approved since the last plan. This entree is checked for cost, labor, acceptability, and nutrients. Acceptability may be a function of when the entree was last served in addition to any normally considered measure of acceptance. A second entree is selected based on compatibility with the first entree. There are five general components of a meal: entrees, starches, vegetables, salads, deserts, and "others"; therefore, this procedure is repeated for each. As each recipe is added to the list, it is checked for compatibility with all the previously selected recipes.

(4) Lunch menus are planned in the same manner as dinner menus, as are breakfast menus, except that breakfast menus generally consist of several entrees, but no vegetable or salad (see Appendix D).

(5) Short order menus are planned last since they have very little variety. The only variation between short order menus is usually the dessert and a specialty sandwich.

(6) After completing the first day's menu, each day of the cycle is planned until all 42 days are completed. The menu plan is then costed against the BDFA. If the cost is satisfactory and the nutritional breakdown is adequate, then the menu plan is ultimately published in monthly editions along with a recapitulation and issue chart.

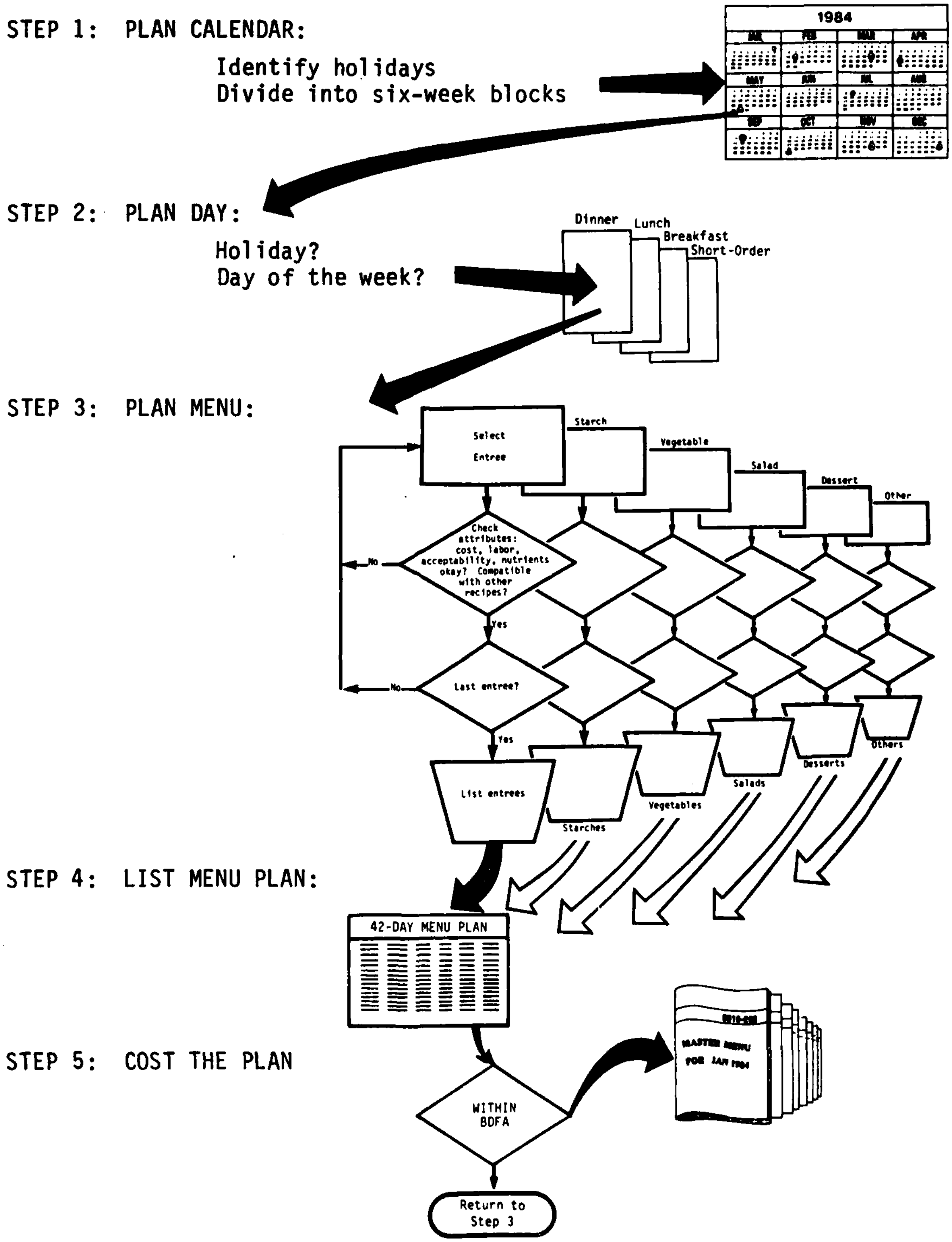


Figure 2-3. TSA Menu Planning Process

g. The menu planning process as outlined above and as illustrated in Figure 2-3 is certainly not complete, but it does give an indication of the steps involved in producing a menu plan. The important thing to note is that each step in the process requires a considerable amount of knowledge and experience in such areas as recipe compatibility, nutrition, diner preference, etc. The methodology developed in the following chapter is aimed at reducing the subjectivity of the process just described and providing the menu planners with an efficient planning tool capable of rapidly and accurately responding to changes in cost, nutritional equirements, and preference patterns.

CHAPTER 3

STUDY METHODOLOGY

3-1. INTRODUCTION. This chapter provides an overview of the factors contributing to the study approach and a discussion of the analytic elements of the study methodology. The application of the methodology to produce menu plans and reports is also discussed.

3-2. BACKGROUND AND PROBLEM ORIENTATION. The Master Menu is important as a guide because, although deviations are allowed, the food service sergeant must rely on the Master Menu to provide for nutritional adequacy, general acceptability, and relative cost efficiency. The actual use of the Master Menu varies throughout the Army. The availability of subsistence items on a local basis may preclude the use of certain menus, but because the food plan is based on the Master Menu, most items required by the Master Menu are available. In addition, the level of training and experience of food service personnel will vary significantly. The experienced food service sergeant may be able to deviate from the Master Menu while still providing an acceptable, nutritious diet within the BDFA; however, most commanders insist that the Master Menu be followed as closely as possible in order to ease the managerial burden on the food service sergeant. Close adherence to the Master Menu also precludes the problem of serving highly acceptable, expensive meals at the start of the month and then skimping toward the end of the month. All of this goes to say that the Master Menu is an important product. It is a product that is needed not only for keeping costs under control but also for maintaining the health and morale of the individual soldier.

a. Considering the importance of the Master Menu, it is necessary that a consistent approach be taken to assure the adequacy of that menu. Considerable work has been done by the US Army Natick Labs in many areas of food service. The results of that work have contributed to our knowledge concerning food preferences, nutrition, and resource availability, but no clear link has been established that would enable this knowledge to be consistently applied to the question of planning the Army Master Menu. In addition, the Troop Support Agency has considerable data concerning recipe acceptability and labor requirements. Again, although this information is available to the menu planners, there is no mechanism for applying it to the design of the Master Menu.

b. As mentioned in the previous chapter, computerized menu planning is not new, but its application has been limited. The introduction of any computerized menu planning system necessitates some changes in thinking and organization. The amount of change that must take place depends on how well the computerized system fits in with the existing menu planning system. In addition, the amount of training and experience required of the menu planner who will be running the new system will be dependent on the design and complexity of the programs involved.

3-3. ANALYTIC METHODOLOGY SELECTION. Menu planning is clearly a process involving a large number of parameters. It is not sufficient to attempt to design a menu that is assured of only being adequate in terms of meeting the minimum requirements. Nor is it sufficient to attempt to optimize a single factor such as cost or preference. Menu planning is a multicriteria problem and should be approached through techniques that are intended to deal with multicriteria problems. A menu may be designed in consideration of the four objectives shown in Figure 3-1; and therefore the need is to employ an analytic methodology that is capable of coming "as close as possible" to satisfying all four objectives. This discussion leads to the conclusion that what is needed is a multicriteria optimization procedure that is responsive to changes in the priority order in which the objectives may be considered. Goal programing is such a procedure. As stated by Prof. James P. Ignizio in "Goal Programming and Extensions": "Goal programing allows one to extend the capabilities of mathematical models so as to encompass decisions involving multiple objectives. This is accomplished by assigning, to each objective, a priority (actually a preemptive priority) that should reflect the priorities of the decisionmaker . . .. If such priorites can be established, rather straightforward mathematical techniques for problem solution are available . . .."

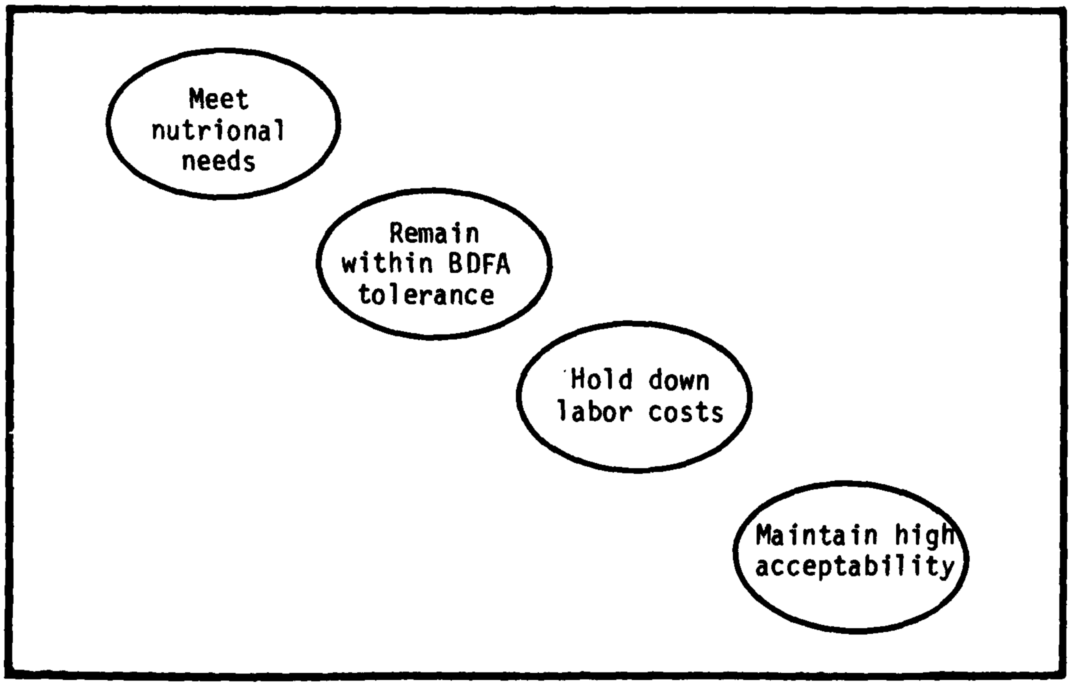


Figure 3-1. The Army Master Menu Objectives

a. Goal Programing Concept. The goal programing methodology is based on an attempt to achieve each goal in a preemptive fashion. Prioritizing the four goals shown in Figure 3-1 implies that one is preferred to another, which is preferred to another, etc. Preemptive prioritization implies that one is preemptively or infinitely preferred to another. This means that the second priority goal may be achieved only as long as its achievement does not reduce the achievement of the first priority goal. The relative achievement of a goal is measured by the positive or negative deviation from that goal. From this it can be seen that the aim in goal programing is to minimize the deviation from the various goals, and with conflicting goals, the reordering of priorities can lead to entirely different solutions.

b. Goal Programing Terminology. As with any complex subject, terminology can be a source of confusion. Fortunately, most of the goal programing terminology is extended from logical concepts of goals, objectives, and deviation. The terminology may even be confusing for those who are familiar with linear programing (LP). While there are some new terms and concepts, most of the confusion stems from semantic differences. Those terms necessary for an understanding of goal programing are as follows:

(1) Decision Variables. These are factors over which some control may be exercised. The value of these factors is determined at the end of the optimization process. In the menu planning process, the decision variables could be identifiable menu combinations.

(2) Attributes. Also referred to as parameters, these are factors by which various decision variables may be distinguished. As an example, if food cost is an attribute, one menu may cost $100.00 to serve 100 persons while another may cost only $60.00 per 100 servings.

(3) Goals. These are quantities that reflect either known limited resources such as total available dollars, or estimated target values such as a measure of acceptance high enough to satisfy the individual. The desired level of achievement of a goal may be related to the goal in one of three ways:

(a) Less than, or equal to ($\leq$) a goal.

(b) Greater than, or equal to ($\geq$) a goal.

(c) Exactly equal to (=) a goal.

(4) Deviation Variables. The concept of deviation variables is at the foundation of goal programing. It is normally not possible to achieve all goals, especially if there is a conflict among the goals. There must, therefore, be some measure of over- or underachievement. This measure is the deviation variable. A positive (p) and a negative (n) deviation variable may be associated with any goal. This implies that if the positive deviation variable takes on a value, then the associated goal is exceeded. If the negative deviation variable takes on a value, then the goal is higher than the level of achievement. If neither the positive nor negative deviation variable has a value, then the goal is exactly met. From this it may be seen that if one wants to be less than or equal to a goal, the positive deviation variable should be minimized. The negative deviation variable should be minimized if one wants to be greater than or equal to a goal; and both should be minimized if one wants to exactly achieve a goal.

(5) Objective Function. An objective function is a mathematical representation of an objective. It combines decision variables, deviation variables, and goals. Objective functions can represent cost constraints, acceptability requirements, labor objectives, nutritional requirements, or any other measure of effectiveness.

(6) Priority Levels. As discussed earlier, the objectives may be prioritized into several different levels. The order in which these objectives are prioritized reflects the relative importance attached to achieving the various goals. In the case of equally important objectives, they may be placed in the same priority level.

(7) Achievement Function. The achievement function is a composite of the deviational variables associated with the various goals of the problem. The achievement function is not in the strictest sense one function, but a combination of functions associated with each priority level. Table 3-1 summarizes the GP terminology and relates, where applicable, the LP terminology along with examples in the menu planning context.

Table 3-1. Goal Programing Terminology

GP terminology	Generic description	Related linear programing term	Example in menu planning context
Decision variables	The unknowns to be determined	Decision variables	Numbers of menus, B-001, L-056 etc.
Attributes	The parameter or descriptors of the decision variable	Same or technological coefficients	$/meal
Goals	The constraining value or aspiration level of the measure of effectiveness	Right hand side values	BDFA, man-hours, calories, etc.
Deviation variables	The unknown value which will take on "other than zero" values if the goals are not exactly met	Equates mathematically to slack and surplus variables	Negative deviation, positive deviation
Objective functions	Defines the MOE of system as a mathematical function of the decision and deviation variables	Constraints	Combination of selected menus must remain within BDFA
Priority levels	Groups and relates the objective functions	No LP equivalent	Objective functions 1,2,4 in priority level 1 and objective functions 3,5,6 in priority level 2, etc.
Achievement function	The optimization functions which attempt to minimize the positive and negative deviations from the prioritized goals	No LP equivalent	
Not used	The LP optimization function	Objective function	Minimize labor manhours, maximize acceptability, etc.

c. Generation of the Problem Matrix

(1) General Model Structure. Mathematical programing models are characterized by a fairly rigid structure. In general, a model is characterized by one or more objective functions followed by a set of constraining equations. Some of these constraining equations may be in the form of bounds such as requiring that a particular variable not exceed a certain value. Each equation except the objective function has a right-hand side (RHS) value. Each equation or function is considered to be a row, while each variable constitutes a column. Bounds are considered separately and RHS values are associated with their corresponding rows. In goal programing models, each row (objective function in GP terminology) has an associated positive and negative deviation variable. As mentioned earlier, the achievement function is a function of certain of these deviation variables. A computer program called the matrix generator has the job of representing this structure to the solution algorithm in such a way that the problem is completely defined. This may be done by listing the model in four data sections: ROWS, COLUMNS, BOUNDS, and RHS. The data produced by the matrix generator, as shown in the examples which follow, are in the format used by the UNIVAC Functional Mathematical Programing System (FMPS) and several other mathematical programing systems.

(a) ROWS Data. ROWS data identifies the sources to be assigned to the rows of the matrix as well as the type of row (equality, inequality, or nonrestraining). In GP there are no inequality type rows. An objective function may be a nonrestraining row. A sample ROWS entry is as follows:

```
E     ACB
```

where the E means an equality type row and ACB is the row name (for acceptability, breakfast).

(b) COLUMNS Data. COLUMNS data specifies the names to be assigned to the columns (variables) in the problem matrix, the rows in which those variables have a nonzero coefficient, and the value of the coefficient. A sample COLUMNS entry is as follows:

```
NEGACB      ACB      1.0
```

where NEGACB is the variable name (negative deviation variable associated with acceptability, breakfast), ACB is a row in which that variable appears, and 1.0 is the value of the coefficient.

(c) BOUNDS Data. BOUNDS data imposes limits on the value that the variable may assume. There are three types of bounds: lower bounds, upper bounds, and fixed values. A sample bounds entry is as follows:

UP BOUND B-001 4.0

where UP BOUND is the type bound, B-001 is the variable (breakfast 1), and 4.0 is the value of the upper bound. This bound means that breakfast menu #1 may not be served more than four times in the cycle.

(d) RHS Data. RHS data identifies the name of a row and the value of the righthand side (goal) for that row. A sample RHS entry is as follows:

RHS FCB 2914.80

where FCB is the row name (food cost, breakfast) and 2914.80 is the RHS value. This means that the food cost goal for breakfast is $2,914.80 for this particular plan.

(2) Master Menu Model Structure. The matrix generator developed under this study takes advantage of the special problem structure associated with the Master Menu Model. That model is presented here (Table 3-2):

Table 3-2. Master Menu Model
(page 1 of 5 pages)

Decision Variables:

X_j : The number of meals of type j, j = 1, 2,..., D

$X_1, X_2, \ldots, X_B$: Breakfast menus

$X_{B+1}, X_{B+2}, \ldots, X_S$: Short Order menus

$X_{S+1}, X_{S+2}, \ldots, X_L$: Lunch menus

$X_{L+1}, X_{L+2}, \ldots, X_D$: Dinner menus

Problem Formulation:

Find $\bar{X} = (X_1, X_2, X_3, \ldots, X_J, \ldots, X_J)$

so as to minimize:

$$a = g_1(\bar{n},\bar{p}), \ldots, g_k(\bar{n},\bar{p}), \ldots, g_k(\bar{n},\bar{p})$$

AND: $\bar{X}, \bar{n}, \bar{p} \geq 0$

where: a is the achievement vector

n is any negative deviation associated with a particular goal, i.e., n_{ACB} is the negative deviation from the breakfast acceptability goal.

p is any positive deviation associated with a particular goal.

$g_k(\bar{n},\bar{p})$ A linear function of the deviation variables associated with priority level k.

Table 3-2. Master Menu Model
(page 2 of 5 pages)

SUCH THAT:

For Acceptability:

$$\sum_{j=1}^{B} AC_j X_j \geq ACB$$

$$\sum_{j=B+1}^{S} AC_j X_j \geq ACS$$

$$\sum_{j=S+1}^{L} AC_j X_j \geq ACL$$

$$\sum_{j=L+1}^{D} AC_j X_j \geq ACD$$

where: AC_j = Acceptability of menu j.

ACB = Breakfast acceptability goal
ACS = Short Order acceptability goal
ACL = Lunch acceptability goal
ACD = Dinner acceptability goal

AND:

For Food Cost:

$$\sum_{j=1}^{B} FC_j X_j = .2FCT$$

$$\sum_{j=B+1}^{S} FC_j X_j = .24FCT$$

$$\sum_{j=S+1}^{L} FC_j X_j = .16FCT$$

$$\sum_{j=L+1}^{D} FC_j X_j = .4FCT$$

where: FC_j = Food Cost of menu j.

FCT = Total Food cost goal
FCT = BDFA * 100 * 42
BDFA is the Basic Daily Food Allowance

Table 3-2. Master Menu Model
(page 3 of 5 pages)

AND:

For Labor Cost:

$$\sum_{j=1}^{B} LC_j X_j \leq LCB$$

$$\sum_{j=B+1}^{S} LC_j X_j \leq LCS$$

$$\sum_{j=S+1}^{L} LC_j X_j \leq LCL$$

$$\sum_{j=L+1}^{D} LC_j X_j \leq LCD$$

where: LC_j = Labor in manhours required to prepare menu j.

LCB = Breakfast labor goal
LCS = Short Order labor goal
LCL = Lunch labor goal
LCD = Dinner labor goal

AND:

For Nutrition:

Calories;

$$\sum_{j=1}^{B} N_{1j} X_j + .6 \sum_{j=B+1}^{S} N_{1j} X_j$$
$$+ .4 \sum_{j=S+1}^{L} N_{1j} X_j + \sum_{j=L+1}^{D} N_{1j} X_j = TN_1$$

Table 3-2. Master Menu Model
(page 4 of 5 pages)

Breakfast fat/calorie ratio;

$$9 \sum_{j=1}^{B} N_{3j}X_j - .4 \sum_{j=1}^{B} N_{1j}X_j \leq 0$$

Short order fat/calorie ratio;

$$9 \sum_{j=B+1}^{S} N_{3j}X_j - .4 \sum_{j=B+1}^{S} N_{1j}X_j \leq 0$$

Lunch fat/calorie ratio;

$$9 \sum_{j=S+1}^{L} N_{3j}X_j - .4 \sum_{j=S+1}^{L} N_{1j}X_j \leq 0$$

Dinner fat/calorie ratio;

$$9 \sum_{j=L+1}^{D} N_{3j}X_j - .4 \sum_{j=L+1}^{D} N_{1j}X_j \leq 0$$

All other nutrients;

$$\sum_{j=1}^{B} N_{ij}X_j + .6 \sum_{j=B+1}^{S} N_{ij}X_j + .4 \sum_{j=S+1}^{L} N_{ij}X_j + \sum_{j=L+1}^{D} N_{ij}X_j \geq TNi,\ i=2,3...,10$$

where: N_{ij} = Amount of nutrient i in menu j.

TN_i = Goal for nutrient i

Table 3-2. Master Menu Model
(page 5 of 5 pages)

AND:

Structurally:

$$\sum_{j=1}^{B} X_j = CL$$

$$\sum_{j=B+1}^{S} X_j = CL$$

$$\sum_{j=S+1}^{L} X_j = CL$$

$$\sum_{j=L+1}^{D} X_j = CL$$

where: CL = cycle length in days

while:

$X_j \leq UBB,\ j = 1, 2, \ldots, B$

$X_j \leq UBS,\ j = B+1, B+2, \ldots, S$

$X_j \leq UBL,\ j = S+1, S+2, \ldots, L$

$X_j \leq UBD,\ j = L+1, L+2, \ldots, D$

where: UBB is the upper bound on the number of times any one breakfast menu may be repeated
UBS upper bound on short order menus
UBL upper bound on lunch menus
UBD upper bound on dinner menus

(a) Priority Levels. While the model may appear complex, the problem is divided into five priority levels: structural, acceptability, food cost, labor cost, and nutrition. The order in which these levels are prioritized is not important except that structural objective functions are always first.

(b) Achievement Function. As mentioned earlier, the achievement function is not truly a function, but a combination of functions, of the type $g_k(\bar{n}\bar{p})$ as defined in the table. As will be explained in the discussion on the GP algorithm in Chapter 5, these functions are to be treated as objective functions in the traditional LP sense.

(c) Structural Equations. The structural equations are rigid constraints. They must be met; therefore, they must always be associated with the first priority. The structural equations impose the requirement that breakfast, lunch, short order, and dinner menus be served every day. Since these are equality type constraints, the matrix generator adds a negative and positive deviation variable to each structural row. In addition, the objective of the first priority problem is to minimize the sum of all the deviation variables associated with the structural rows.

(d) Acceptability. The acceptability equations are objective functions in the GP sense. Since these equations are all greater than or equal to ($\geq$) type rows, positive and negative deviation variables are added to each, but the g_k associated with acceptability is a function of only the negative deviation variables.

(e) Food Cost. The food cost equations are equality type rows since the goal is to meet the BDFA and not simply hold down costs. As a result the g_k associated with food cost is a function of both the positive and negative deviation variables.

(f) Labor Cost. Since these equations are all less than or equal to ($\leq$) type rows, positive and negative deviation variables are added to each, but the g_k associated with labor cost is a function of only the positive deviation variables.

(g) Nutrition. Each nutritional goal is to be met or exceeded except the calorie goal which is to be met due to an emphasis on weight control. In addition AR 30-1 states that the desirable proportion of total caloric intake from fat sources is less than 40 percent. This goal is reflected in the fat/calorie ratio equations since there are 9 calories per gram of fat. The fact that lunch and short order menus are to be served concurrently, with a 60 percent preference for the short order meal, is also reflected in these equations. Because of the way in which the nutritional goals are handled, the matrix generator causes the g_k associated with nutrition to be a function of the positive and negative deviation variables associated with the calorie row, the positive deviation variables associated with the fat/calorie ratio rows, and the negative deviation variables associated with the other nutrient rows.

d. Generation of Menu Attributes. The methodological approach as outlined in this chapter assumes that there is some variable over which control may be exercised in order to influence the adequacy of the menu plan as measured by the set of attributes. These are the decision variables, and there are two possible candidates: (1) the number of times that each recipe is served, or (2) the number of times that each menu is to be served during the menu cycle. The advantage of using recipes is that there is a set list of available recipes from which to choose, each with some known attribute values. The disadvantage is that there is little quantifiable data concerning the compatibility of recipes. The problems associated with designing a recipe-based model are myriad as compared to those of designing a menu-based model. Of course, it is possible to have an almost unlimited set of menus from which to choose. In practice, however, there is a fairly limited set of menus--those that have been developed over years of experience. The process of combining recipes into menus is in the realm of the menu planner, while the selection of the best combination of menus to be served in a cycle is the function of the menu planning model developed under this study. The fact that the model is not recipe-based is not necessarily a limitation as long as two factors are considered: (1) there is a representative sampling of menus from which to choose, and (2) the menu attributes adequately represent the effect of combining those recipes that comprise each menu. Concerning the first factor, this sampling cannot possibly be all-inclusive, but it must include a number and variety of menus sufficient to provide for a broad choice in the optimization process. The second factor is considered in the generation of the menu attributes. The determination of the values of the menu attributes is based on appropriate linear combinations of all recipe attribute values. Each attribute is treated separately.

(1) Acceptability. The recipes of a menu fall into six general categories which may be called menu components: entrees, starches, vegetables, salads, deserts, and "others". A 1975 study by the Natick Labs suggests that the overall acceptability of a menu may be determined through a weighted combination of the first five menu components listed above. In that study, the weights were determined to be as shown in Table 3-3. Since, in any one menu, there may be several recipes that fall into a particular category or menu component, it is necessary to compute the overall acceptability of the menu component.

Table 3-3. Normalized Weights of Five Meal Components

	Entree	Starch	Vegetable	Salad	Dessert
Percent of total weight	.49	.16	.12	.07	.16

(a) In determining the acceptability of a particular menu component such as the entree, the concern is that not all of the entrees will be rejected. If PE_i is the probability of accepting entree i, then $(1-PE_i)$ is the probability of rejecting entree i and

$$\prod_{i=1}^{n} (1-PE_i)$$

is the probability of rejecting all n entrees. Therefore, the acceptability of the entree portion of the menu (Ae) is:

$$Ae = 1- \prod_{i=1}^{n} (1-PE_i)$$

As shown in Table 3-4, this means that a meal consisting of two entrees--creole macaroni with an acceptability of 40 percent and braised beef short ribs with an acceptability of 80 percent--would have an overall entree acceptability of 88 percent. Based on the assumptions that only one entree may be selected, it can be expected that 2/3 of the diners will select the short ribs while 1/3 will select the macaroni.

Table 3-4. Acceptability Computation Procedure

	Acceptability	Probability of acceptance	Item weight
Creole macaroni	40%	.4	40/120 or 1/3
Braised beef short ribs	80%	.8	80/120 or 2/3

P(rejecting macaroni) = 1-.4 = .6
P(rejecting ribs = (1-.8) = .2
P(not rejecting both) = (1-(.6)(.2)) = .88
Therefore, acceptability of entree is 88%

(b) A sample dinner menu (D-001) with associated attribute values is listed in Table 3-5. An example of the acceptability calculations for menu D-001 is shown in Table 3-6.

(c) Short order menus typically do not include vegetables and therefore the weighting factors of Table 3-3 are renormalized for four meal components and are shown in Table 3-7. The acceptability of the breakfast meal is determined entirely by the acceptability of the entrees. Since breakfast menus include several entrees, the probability of rejecting all of them is very low; therefore, breakfast menus typically are very high in acceptability.

Table 3-5. Recipe Attributes of Sample Dinner Menu D-001

Recipe	Meal component	Acceptability factor (%)	Food cost $/100 serv	Labor cost manhours/ 100 serv	Calories/ 100 serv
Hot tea	Other	15.0	$.60	.64	0
Coffee	Other	40.0	4.38	.71	877
Hot rolls	Other	40.0	4.50	1.68	24,175
Butter wash	Other	20.0	3.00	.74	6,495
Frosting	Other	35.0	3.71	1.22	12,354
Pie	Dessert	45.0	16.93	2.89	50,787
Perch	Entree	50.0	50.24	2.21	29,936
Ham steaks	Entree	50.0	59.70	2.26	26,250
Potato salad	Salad	45.0	6.44	2.06	18,753
Spring salad	Salad	40.0	7.85	1.43	1,250
Salad dres.	Other	16.0	3.19	2.00	17,212
Cole slaw	Salad	40.0	3.32	2.24	6,930
FF eggplant	Vegetable	20.0	6.00	2.37	8,095
O'Brien potatoes	Starch	30.0	6.27	1.76	20,073
Brussel sprouts	Vegetable	30.0	8.90	1.51	5,287
Lemon cake	Dessert	40.0	2.42	0.00	9,935
Butter	Other	95.0	3.00	.50	6,496
Milk	Other	75.0	15.36	.58	31,713
Soft drinks	Other	65.0	40.00	.58	19,905

Table 3-6. Sample Computation - Acceptability of Menu D-001

Acceptability of Entree Component (Ae) = (1-(.5)(.5)) = .75

Acceptability of Starch Component (A_{st}) = 1-.7 = .30

Acceptability of Vegetable Component (A_v) = 1-(.8)(.7) = .44

Acceptability of Salad Component (A_{sl}) = 1-((.6)(.6)(.55)) = .80

Acceptability of Desert Component (A_d) = 1-((.55)(.6)) = .67

Acceptability of Menu D-001 (Am):

$$A_m = .49(Ae) + .16(A_{st}) + .12(A_v) + .07(A_{sl}) + .16(A_d)$$

$$= .49(.75) + .16(.30) + .12(.44) + .07(.80) + .16(.67)$$

$$= .6316$$

Therefore, the acceptability of menu D-001 expressed as a percentage is 63.16 percent.

Table 3-7. Normalized Weights of Four Meal Components for Short Order Menus

	Entree	Starch	Salad	Dessert
Percent of total weight	.56	.18	.08	.18

(2) Food Cost. The computation of the food cost of a menu is a weighted linear combination of the cost of the recipes comprising the menu. The weights to be used are determined from the acceptability factors as was shown in Table 3-3. Cost data are in terms of serving 100 persons and, as in the earlier example, it is expected that 2/3 will select short ribs and 1/3 will select macaroni for an entree cost per 100 persons of $21.67. This is shown in Table 3-8. It is assumed that one recipe from each menu component is selected and that those recipes in the "other" category are selected according to their acceptance factor. This means that the food cost of each meal component as computed above is summed with the cost of "other" items reduced by an acceptability factor. An example of these computations for sample menu D-001 is shown in Table 3-9.

Table 3-8. Food Cost Computation Procedure

Entree	Acceptability	Item weight	Food cost
Macaroni	40%	1/3	$5.00
Short ribs	80%	2/3	30.00
Acceptability of entree	88%		
Food cost of entree	5 (1/3) + 30 (2/3) = $21.67		

Table 3-9. Sample Calculations - Food Cost of Menu D-001

Cost of Entrees:

$$FC_e = \frac{1}{2}(50.24) + \frac{1}{2}(59.70) = 54.97$$

Cost of Starch:

$$FC_{st} = 6.27$$

Cost of Vegetable:

$$FC_v = \frac{2}{5}(6.00) + \frac{3}{5}(8.90) = 7.74$$

Cost of Salad:

$$FC_{sl} = \frac{45}{125}(6.44) + \frac{40}{125}(7.85) + \frac{40}{125}(3.32) = 5.89$$

Cost of Dessert:

$$FC_d = \frac{45}{85}(16.93) + \frac{40}{85}(2.42) = 10.10$$

Cost of "Others"

$$FC_o = .15(.60) + .40(4.38) + .40(4.50) + .20(3.00) + .35(3.71) + .16(3.17) + .95(3.00) + .75(15.36) + .65(40.00) = 46.42$$

Total cost of menu D-001:

$$FC_{Total} = FC_e + FC_{st} + FC_v + FC_{sl} + FC_d + FC_o = \$131.40$$

(3) Labor Cost. The labor cost of a recipe is a measure of the number of manhours required to prepare that recipe. As noted in the assumptions of Chapter 1, there is a fixed labor cost for 100 or fewer servings of an item. This implies that it takes as long to prepare most recipes for 60 persons (as an example) as it does for 100 persons. Because of this, the manhours required to prepare a menu is the sum of the manhours involved in preparing the recipes that comprise that menu. The computations shown in Table 3-10 for the macaroni and ribs example illustrate the process.

Table 3-10. Labor Computation Procedure

Entree	Acceptability	Weight	Food cost/ 100	Labor/ 100
Macaroni	40%	1/3	$5.00	3.4 manhours
Short ribs	80%	2/3	30.00	2.7 manhours
Acceptability of entree	88%			
Food cost of entree	$21.67			
Labor cost of entree	3.4 + 2.7 = 6.1 manhours			

(4) Nutrition. Ten nutrients are considered as nutritional attributes in this study. They are shown along with their units of measure in Table 3-11. The procedure for computing the nutritional attributes is exactly the same as for food cost, except that the procedure is applied to each of the 10 nutrients. Sample calculations for a single nutrient, calories, are shown in Table 3-12 as applied to the macaroni and ribs example. Figure 3-2 shows the display of the menu attributes for menu D-001 as the user would see it.

Table 3-11. Nutritional Attributes

Nutrient	Unit of measure
1 Calories	Kcal
2 Protein	gram (gm)
3 Fat	gm
4 Calcium	milligrams (mg)
5 Iron	mg
6 Vitamin A	International units (IU)
7 Thiamin	mg
8 Riboflavin	mg
9 Niacin	mg
10 Vitamin C	mg

Table 3-12. Nutrition Computation Procedure

Entree	Acceptability	Item weight	Food cost/ 100	Labor/ 100	Calories/ 100
Macaroni	40%	1/3	$5.00	3.4mhr	42000.
Short ribs	80%	2/3	30.00	2.7	49000.

Acceptability of entree: 88%
Food cost of entree: $21.76
Labor cost of entree; 6.1 manhours

Calorie content of entree:

1/3(42,000) + 2/3 (49,000)(42k) = 46,667. Kcal/100 servings

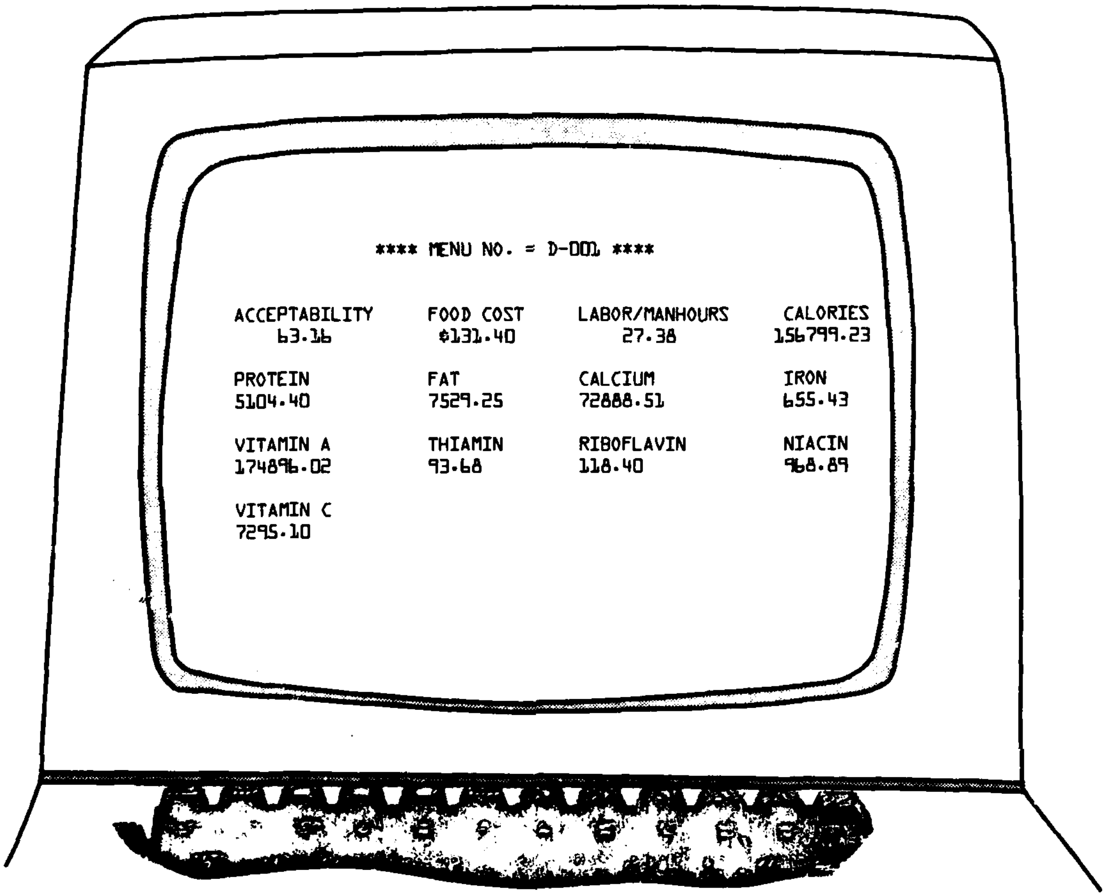


Figure 3-2. Menu D-001, Menu Attributes

e. <u>Concept of User/Model Interface</u>. While the methodological approach of this model is based on goal programing, it is important that the complexity of the goal programing algorithm and other complex procedures not be a deterrent to the effective use of the model. It is necessary, therefore, that the programs that enable the menu planners to employ the model be accurate, efficient, simple to access, and clear in the presentation of information. The design of this system is the subject of Chapter 4.

3-4. PROCEDURAL METHODOLOGY SELECTION. In conjunction with the selection of an analytic methodology, a procedural methodology suited to the scope of the problem was also required. The procedural methodology adopted was based on viewing the menu planning process as consisting of four distinct phases: (1) data retrieval and manipulation, (2) application of planning parameters, (3) selection of menus, and (4) analysis of the menu plan. The study effort was conducted in corresponding phases. The first phase consisted of data collection and the design of interactive routines that facilitate data retrieval and manipulation. The second phase consisted of establishing the parameters to be employed in the process of designing menu plans. This phase included meetings with ODCSLOG and TSA personnel who were included in the food service field. It also included discussions with people currently involved in computerized menu planning, including those at Natick Labs and representatives of the private sector. The third phase was the design of a mathematical model and a sophisticated goal programing algorithm. This phase required contact with several authorities in the field of mathematical programing. The final phase consisted of designing a postprocessor that presents the menu planner with sufficient information from which to make judgments concerning resource tradeoffs. This phase also included an analysis of the menu plans generated from the sample data provided by TSA. Each of these phases is discussed in detail in later chapters.

3-5. SUMMARY. To address problems involved in planning the Army Master Menu, a methodology and associated model were developed that enable the menu planner to design menu plans through consistent analytical considerations of food cost, labor, acceptability, and nutritional adequacy. The analytic methodology is based on the selection of a set of menus that best satisfies goals for each of the above attributes. The menu planner is provided with a tool that is not only efficient and accurate, but also simple to use.

CHAPTER 4

SYSTEM DESIGN

4-1. INTRODUCTION. The Master Menu Study resulted in the development of two main products: (1) a methodology, and (2) a model. The methodology, as explained in the previous chapter, conceptualized the process of designing menus. The model, as described in this chapter, puts those concepts into operation. The model is the Econometric Model for Optimizing Troop Dining Facility Operations. More simply (and more to the point) it is called the Master Menu Model. The purpose of the model is to plan the Master Menu, but, in addition, it may be used to plan menus of varying cycle length with goals that are very different from those of the Army Master Menu. The purpose of such flexibility is to provide a design tool that will allow the menu planner and analyst to experiment with different concepts and to identify resource tradeoffs. A key to taking advantage of the flexibility of the model is an understanding of the system design.

4-2. DESIGN CONSIDERATIONS. In addition to the requirements of any software development effort, there were several special requirements to be considered in the design of the Master Menu Model.

a. Portability. Because the model was to be developed at CAA and placed into operation at TSA, portability was a prime concern.

(1) CAA has a UNIVAC 1100/82 with a word length of 36 bits and character representation in both ASCII and Fieldata. TSA, on the other hand, has a Burroughs 6800 with a 48-bit word and EBCDIC character representation. The use of standard FORTRAN 77 as the programing language eliminated most of the compatibility problem although some differences in the intrinsic functions, hashing algorithms, and sort routines had to be overcome.

(2) The main problem in the area of portability concerned the development of a goal programing algorithm. There are two general approaches to goal programing. One is the use of a multiphase simplex algorithm. These algorithms are generally efficient and portable, but are only capable of accurately handling small problems limited to fewer than 100 objective functions and 100 variables. Since it was anticipated that the menu planning model would be somewhat larger, these algorithms were not satisfactory. The second approach to goal programing is the use of a procedure called sequential linear goal programing (SLGP). SLGP was used in a previous study at CAA and was very successful in that it took advantage of the sophisticated Functional Mathematical Programing System (FMPS) that was available on the UNIVAC. Unfortunately, FMPS was not portable, and the cost of acquiring a comparable package for the Burroughs was considered to be prohibitive. Portable LP packages that are capable of efficiently solving large-scale problems are not common

although a few have been developed just recently. Among the LP packages considered for use in the model were those shown in Table 4-1. XMP was selected because it is portable, yet capable of efficiently solving large problems. An introduction to the XMP package is provided at Appendix E. The fact that it consists of a library of FORTRAN subroutines added to its flexibility and therefore the ease of modifying it to perform sequential linear goal programing. SPLP probably could have been used, but it was not available in the early stages of the study. XMP has proven to be a very effective, although somewhat complex, tool.

Table 4-1. Alternative LP Packages

Name	Description	Features
XMP	A structured library of subroutines for experimental mathematical programing.	Portable, efficient, flexible, somewhat complex.
MINOS	A nonlinear optimization package capable of solving LP problems.	Semi-portable, efficient, less flexible, complex.
SPLP	A sparse linear programing subprogram	Portable, efficient, flexible, possibly less complex than XMP

b. Flexibility As mentioned earlier, flexibility was a key consideration in the design of the model. Flexibility was not necessarily required of a model that would simply design the Master Menu from established goals and priorities, but was required of a model that was to be used as a design tool capable of rapidly and accurately responding to changes in costs, nutritional requirements and preference patterns. It was also envisioned that the model would be used to experiment with alternative menus and cycle lengths. In fact, some of the flexibility was engendered by questions of a "can it do this?" nature that were brought up during the in-process reviews (IPR) that were conducted with ODCSLOG and TSA personnel. Of course, there is a tradeoff between flexibility and complexity and, as a result, the model has several limitations. In general the model designs menus based on serving 100 individuals in accordance with the policies and procedures of the Army Ration Credit System (ARCS). In addition, no more than 10 nutrients may be considered, although by minor modification those 10 may be changed from those currently considered. Lunch is considered to be served concurrently with the short order menu, and several parameters such as menu component weights are fixed into the model. In addition, the treatment of the way in which goals are achieved is fixed. As an example, the model attempts to exactly meet the food cost goal, but tries to meet or exceed the acceptability goals. This was discussed in detail in Chapter 3 in the section that deals with the matrix generator. Most of these inflexibilities were necessitated by a reed to avoid unnecessary complexity. In many cases, simple changes to the FORTRAN programs can be made when the situation warrants.

c. Integration of the Model with the Existing System. The Master Menu Model is not intended to replicate the menu planning process as outlined in Chapter 2. Instead, it incorporates an alternative approach that is intended to take advantage of the positive aspects of the current system. The current system is based on combining a limited set of recipes into candidate menus within established parameters while attempting to achieve certain goals. The Master Menu Model incorporates the same general process into its design in that it maintains a rapidly accessible data base of recipes, menus, and attributes; allows for the entry of goals for each of these attributes and enables the menu planner to establish priorities. In addition, the model enables the menu planner to eliminate some menus from consideration while requiring the selection of others.

(1) Sequence of Operations. The system design encourages a logical sequence of operations similar to that of the current process. As shown in Table 4-2, the sequence begins with the establishment of a valid set of data from which to work. The menu planners then establish a set of constraints, such as requiring that no dinner menu be repeated in its entirety more than twice during the menu cycle. Goals are established for each of the attributes along with the priority order in which they are to be considered. A menu plan is then generated and evaluated for possible revision. The sequence of operations will be detailed further as each element of the model is described later in this chapter.

Table 4-2. Sequence of Operations

- Establish a valid set of data
- Establish constraints and bounds
- Determine menu planning goals for:
  - Cycle length
  - Food cost
  - Acceptability
  - Labor cost
  - Nutrition
- Order the goals by priority
- Generate the menu plan
- Evaluate the plan

(2) Ease of Operation. For the model to be integrated into the existing menu planning operation, it was clear that it had to be relatively simple to operate. The model incorporates several complex processes, but most of the complexity is hidden from the menu planner. In general, the menu planner is presented with a list of possible steps that may be taken, or is asked to reply to questions with a simple yes or no. When employing the model as a decision tool, it is desirable to be able to change priorities or goals without having to rebuild the data set. This need has been recognized in the design of the model so that the model may be expeditiously rerun. If the value of recipe attributes or the composition of candidate menus has changed, the problem matrix will have to be regenerated.

(3) Speed of Operation. Another essential element of integrating the model into existing operations is the time involved in operating the model. Speed was a prime consideration in the design of the model. Data retrieval routines were designed to interface with direct access files, thereby significantly decreasing response time. Even in the worst case in which an entire data set had to be loaded, the total time required to load a sample set of 1675 recipes with associated attribute data, and 325 menus with associated recipe numbers was less than 8 minutes.

d. Modularity. Storage requirements and the overhead associated with large computer programs were generally unknown in this project because the model was to be transferred from one computer system to another. As a result, the system was modularized as much as possible. There are three main modules: (1) the Data Handling Module, (2) the Parameterization Module, and (3) the Solution Module. The function of each is indicated by its name. Each module is independent of the others, although the output of one may be used as the input for another. In addition, each module is comprised of many subroutines, each with a specific function. This design is intended to ease maintenance requirements and allow for model enhancements.

4-3. THE MASTER MENU MODEL. Before going into any detail on the system design, it is necessary to first get a picture of the model structure. A graphical representation of the model structure is shown in Figure 4-1. The structure represents the logical sequence of operations in menu planning. The user is able to interface with recipe and menu data files in order to maintain and update that data. The preprocessor has the function of generating the menu attribute file through the processes described in Chapter 3. Once the menu attribute file has been created, a set of rigid constraints is implicitly incorporated into the generation of the goal programing problem matrix. A set of upper bounds is initially placed on all menus to preclude excessive repetition; however, the user may alter these bounds, either to require the inclusion of menus at a certain level of frequency, or to restrict other menus from being selected. The user may also select the menu planning goals and priority order. Once the problem matrix has been generated, and menu planning parameters such as bounds, goals and priorities have been established, the solution may be generated through use of the GP solution algorithm. A postprocessor displays the output in a series of five reports. As mentioned earlier, the model is subdivided into three independently operated modules: (1) the Data Handling Module, (2) the Parameterization Module, and (3) the Solution Module.

a. The Data Handling Module. The Data Handling Module, also referred to as the data module, is that portion of the model illustrated in Figure 4-2. As implied by its name, the data module has the general functions of maintaining data files and providing for access to those files.

(1) File Descriptions. A description of each file is necessary before discussing the specific capabilities of the data module.

(a) Recipe Attribute File. The recipe attribute file is a direct access file capable of storing data for up to 4,999 recipes. Each record contains data for one recipe and is divided into fields as shown in Table 4-3.

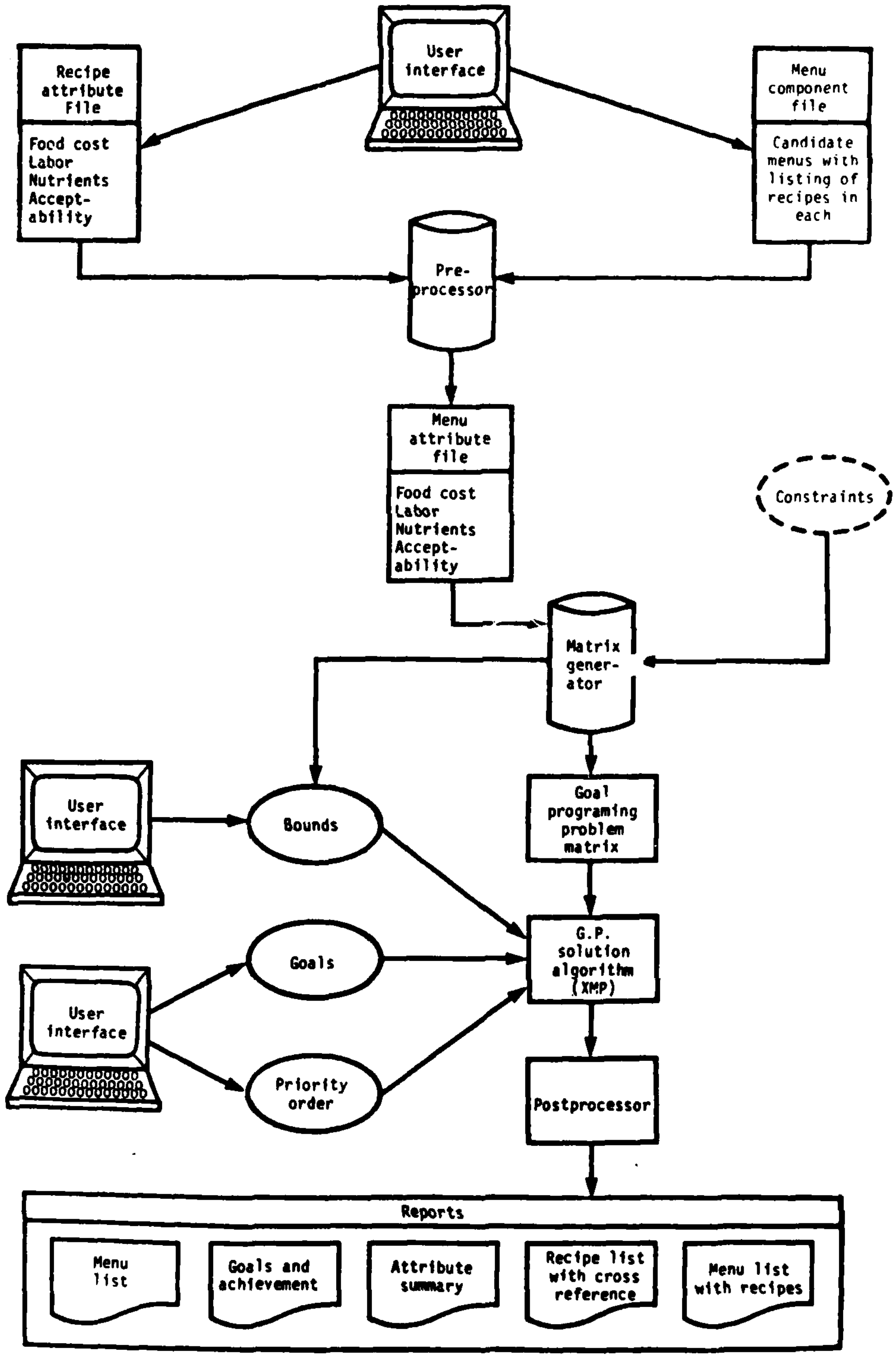


Figure 4-1. Model Structure

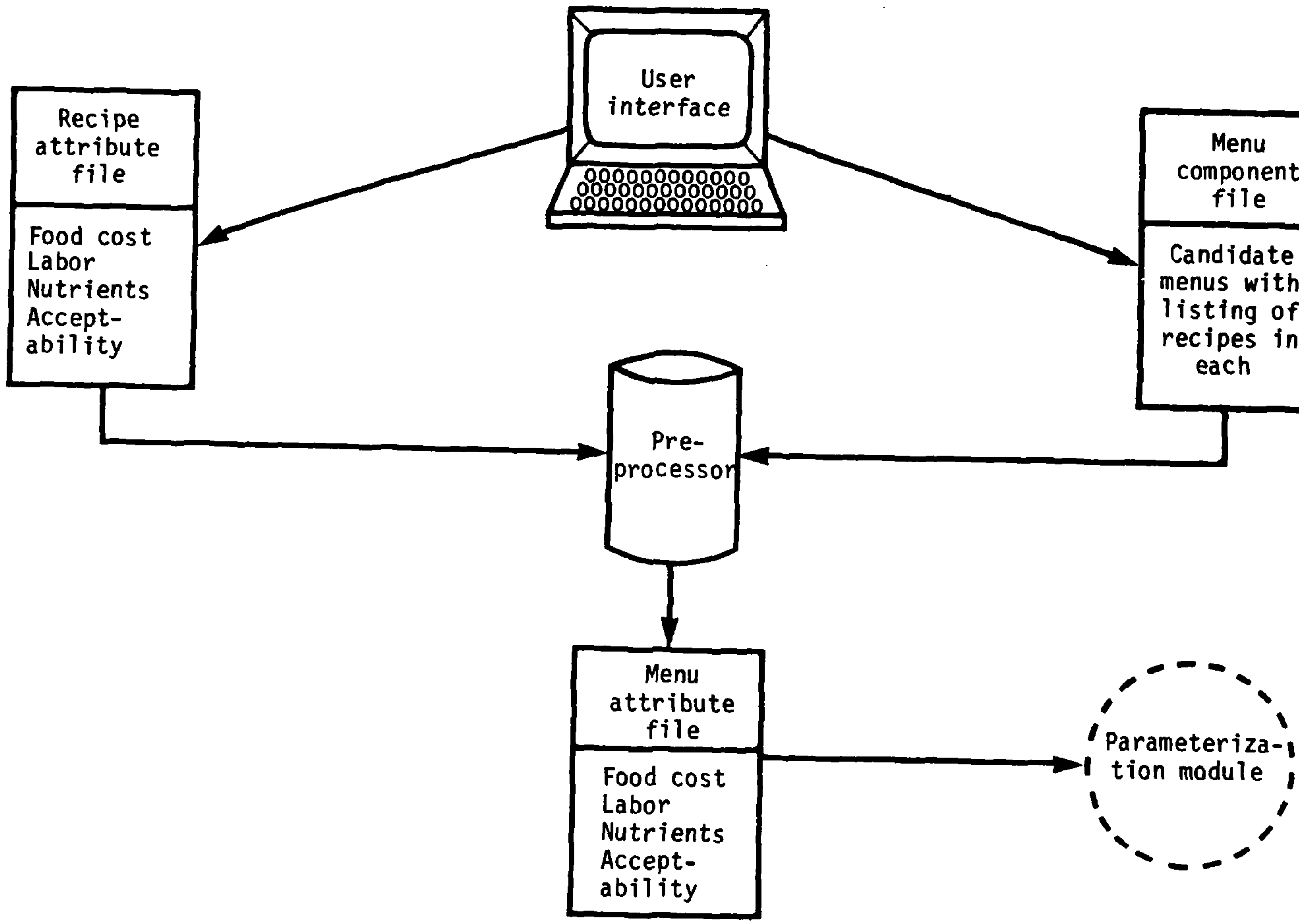


Figure 4-2. Data Handling Module

Table 4-3. Recipe Attribute File

Field	Contents	Comments
1	Index	Indicate by 0 or 1 whether record is empty or not
2	Recipe ID number	As defined in TM 10-412 plus other TSA recipe numbers
3	Recipe name	Up to 30 characters
4	Recipe kind	Three-letter abreviations for entree, vegetable, starch, salad, dessert, other
5	Food cost	$/100 servings
6	Labor cost	Manhours/100 servings
7	Acceptability	Percentage
8	Calories	Calories/100 servings
9	Protein	gm/100 servings
10	Fat	gm/100 servings
11	Calcium	mg/100 servings
12	Iron	mg/100 servings
13	Vitamin A	IU/100 servings
14	Thiamin	mg/100 servings
15	Riboflavin	mg/100 servings
16	Niacin	mg/100 servings
17	Vitamin C	mg/100 servings

(b) Menu Component File. The menu component file is a direct access file capable of storing data for up to 2,999 menus. Each record contains a variable number of fields up to a maximum of 33 as shown in Table 4-4. The menu component file is simply a listing of all the candidate menus and the recipes that comprise each. The implication of the field limitation is that no menu may consist of more than 30 recipes.

Table 4-4. Menu Component File

Field	Contents	Comments
1	Index	Indicate by 0 or 1 whether record is empty or not.
2	Menu ID number	Sequentially ordered and preceded by a letter indicating the type menu Ex.: B-001, B-002, ... L-001, L-002, ... etc.
3	Number of Recipes	The number of recipes in the menu. Maximum = 30.
4-33	Menu ID number	As defined in TM 10-412 or as specified by TSA.

(c) Menu Attribute File. The menu attribute file is a sequential file without specific limitation as to the number of records. Each record contains attribute data for one menu and is divided into fields as shown in Table 4-5.

Table 4-5. Menu Attribute File

Field	Contents	Comments
1	Menu number	Same as menu component file.
2	Acceptability	Percentage
3	Food cost	$/100 servings
4	Labor cost	Manhours/100 servings
5	Calories	Calories/100 servings
6	Protein	gm/100 servings
7	Fat	gm/100 servings
8	Calcium	mg/100 servings
9	Iron	mg/100 servings
10	Vitamin A	IU/100 servings
11	Thiamin	mg/100 servings
12	Riboflavin	mg/100 servings
13	Niacin	mg/100 servings
14	Vitamin C	mg/100 servings

(2) Specific Functions. The data module is capable of performing several specific functions. The user is allowed to choose a particular function by responding to a display similar to that shown in Figure 4-3.

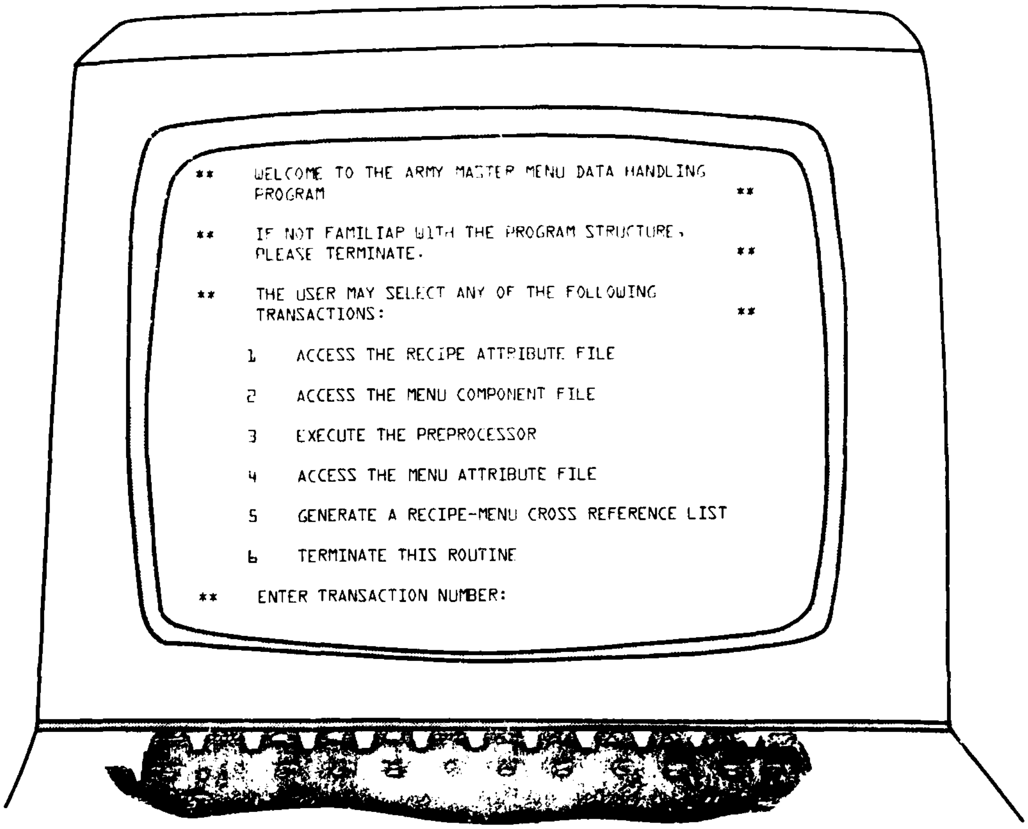


Figure 4-3. Data Handling Module Interface

(a) Accessing the Recipe Attribute File. After accessing the recipe attribute file, the user may choose to take any or all of the following actions.

- List a portion of the file
- Locate individual recipes
- Delete recipes
- Insert recipes
- Modify recipe data
- Load an external data file

(b) Accessing the Menu Component File. After accessing the menu component file, the user may choose to take any of the actions available when accessing the recipe attribute file.

(c) Executing the Preprocessor. The preprocessor generates the menu attribute file from the data in the recipe attribute file and the menu component file. The process is described in Chapter 3.

(d) Accessing the Menu Attribute File. Once the menu attribute file has been created, it is inappropriate to make any change to it. Therefore the user is only given the following choices:

- List all the menus
- List breakfast menus
- List lunch menus
- List dinner menus
- List short-order menus
- List an individual menu

(e) Generating a Recipe-menu Cross-reference Listing. While accessing the menu component file simply provides information as to which recipes appear in each menu, it is also desirable to know in which merus a particular recipe appears. A cross-reference listing provides this information.

(3) Additional files. In addition to the recipe attribute file, the menu component file, and the menu attribute file, other files may be associated with the data module such as internal data files from which the initial data sets may be loaded.

b. The Parameterization Module. The Parameterization Module is that portion of the model illustrated in Figure 4-4. It has the general function of setting up the problem for solution.

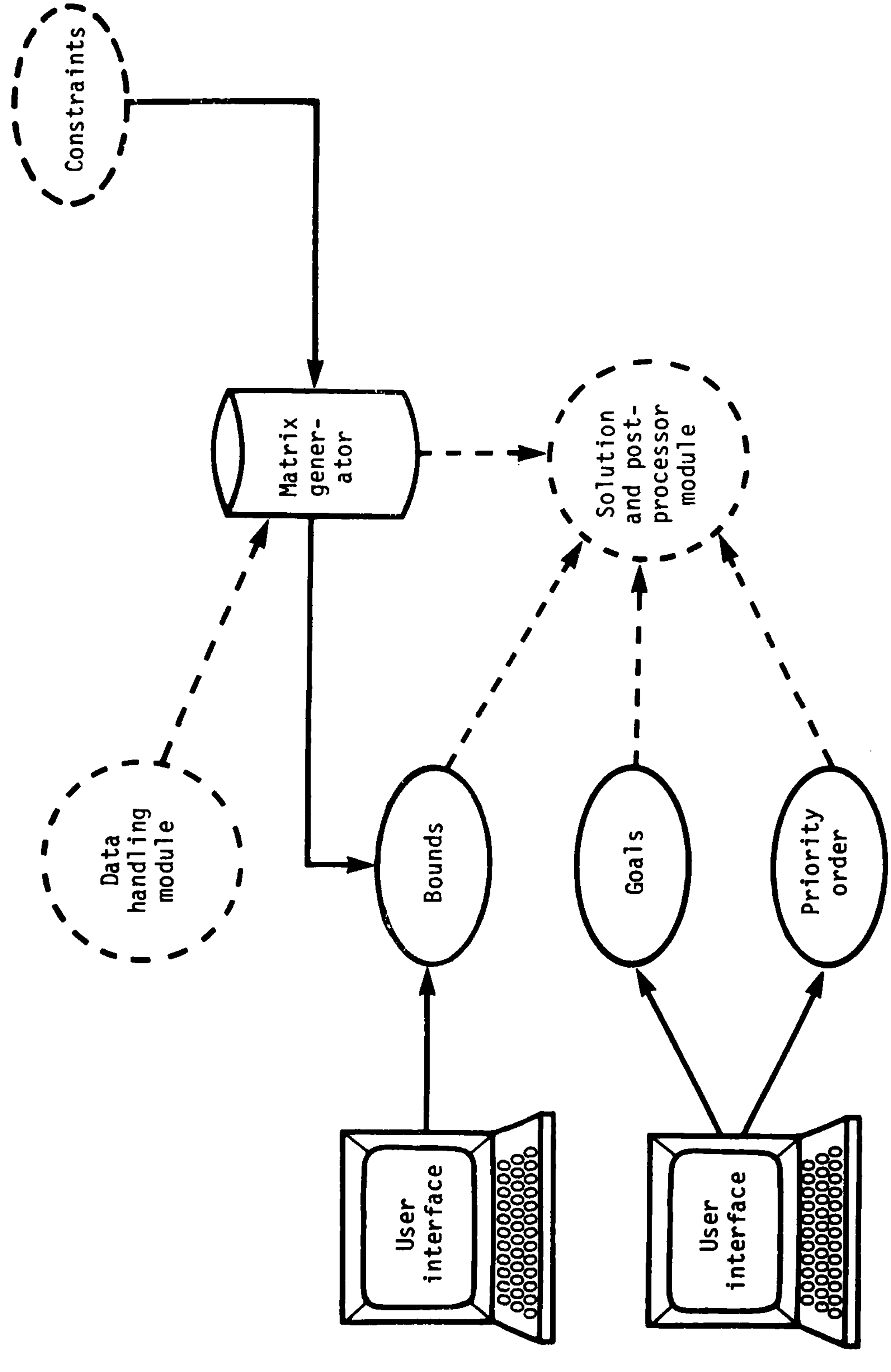


Figure 4-4. Parameterization Module

(1) File Descriptions. Although no data files are pictured in Figure 4-4, several data files of which the user is not normally aware are maintained by the Parameterization Module. These files contain the problem matrix, the menu bounds, menu planning goals, and a listing of priorities. The user interface provides the user with all the necessary information concerning those files.

(2) Specific Functions. The Parameterization Module is capable of performing several specific functions. The user is allowed to choose a particular function by responding to a display similar to that shown in Figure 4-5.

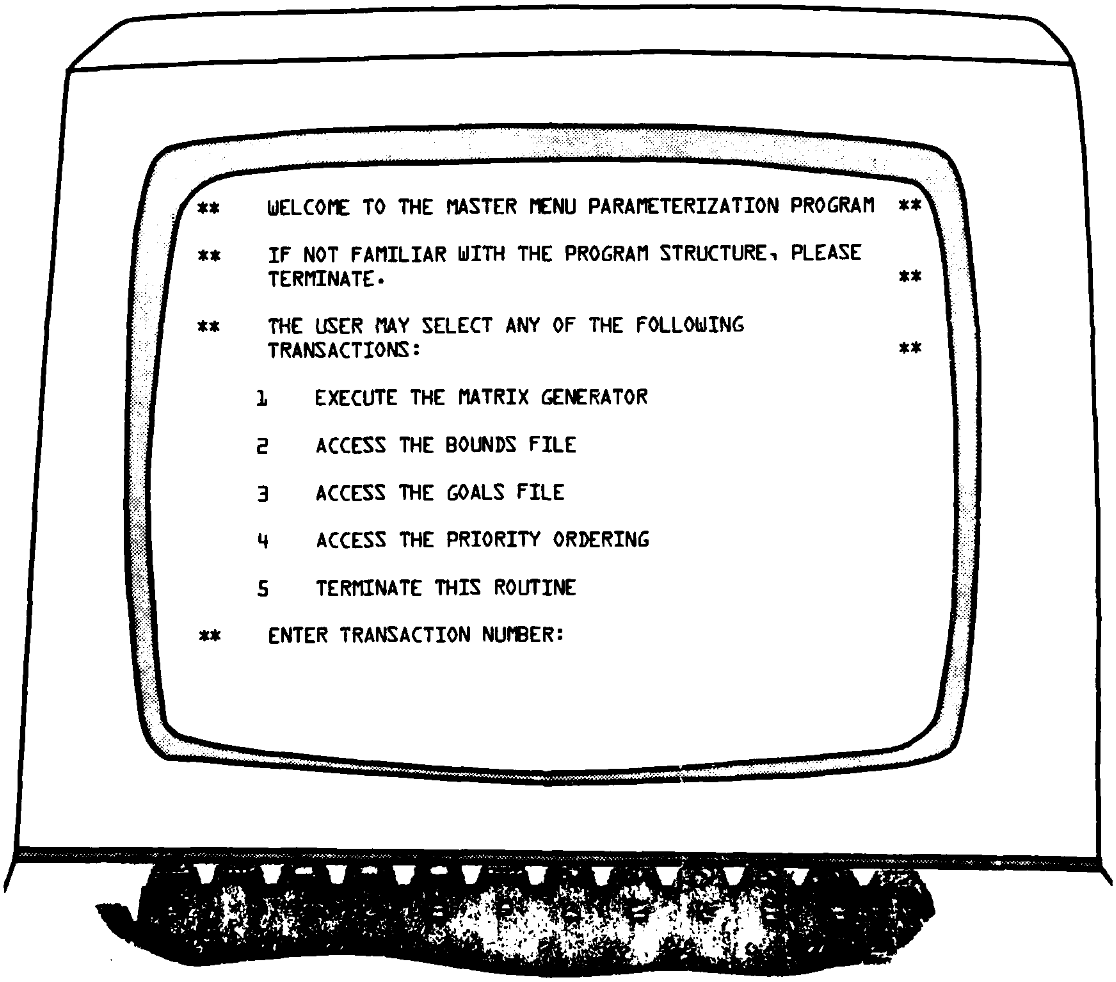


Figure 4-5. Parameterization Module Interface

(a) Executing the Matrix Generator. The matrix generator has the job of displaying the mathematical model in a form that can be understood by the optimization algorithm. As described in Chapter 3, certain rigid constraints are incorporated into the way in which the problem matrix is displayed. In general, the matrix generator uses the data from the menu attribute file as coefficients for the decision variables and supplies the appropriate deviation variables for the problem structure. Before generating the problem matrix, the user is asked to supply general upper bounds. By executing the matrix generator, the user is creating a file containing the problem matrix and a file containing the upper bounds.

(b) Accessing the Bounds File. By accessing the bounds file, the user is given the capability to require that certain menus be included in the solution at a given level, or require that certain menus be eliminated from consideration.

(c) Accessing the Goals File. By accessing the goals file, the user is able to change any of the menu planning goals. An example of the type display seen by the user and those goals that may be changed is illustrated in Figure 4-6.

(d) Accessing the Priority Ordering. By accessing the priority ordering, the user is able to enter the order in which the four menu attributes are to be prioritized by the solution algorithm.

(3) Overview. The Parameterization Module maintains all the information necessary to completely describe the mathematical model: the rows and columns of the problem matrix, the right hand side values (goals), the bounds and the priority order. With this information the menu planning problem can be solved.

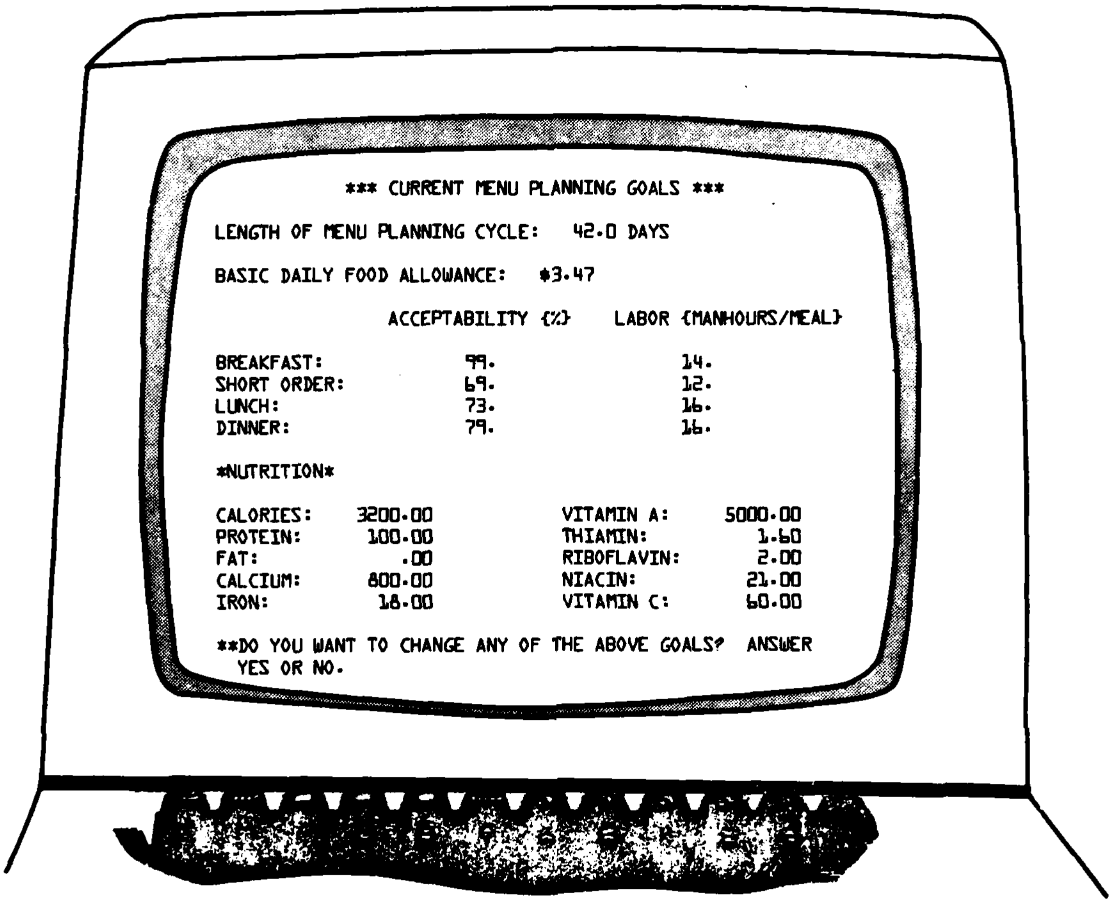


Figure 4-6. Accessing the Goals File

c. Solution Module. The Solution Module is that portion of the model shown in Figure 4-7. As implied by its name, the Solution Module has the general function of solving the menu planning problem. The solution itself only consists of a list of menu numbers followed by the serving frequencies; therefore, a postprocessor has the task of displaying the solution in terms of information meaningful to the menu planner. For this purpose, five reports are generated as the model output. In addition, a cover sheet listing the priority order as shown in Figure 4-8 is produced.

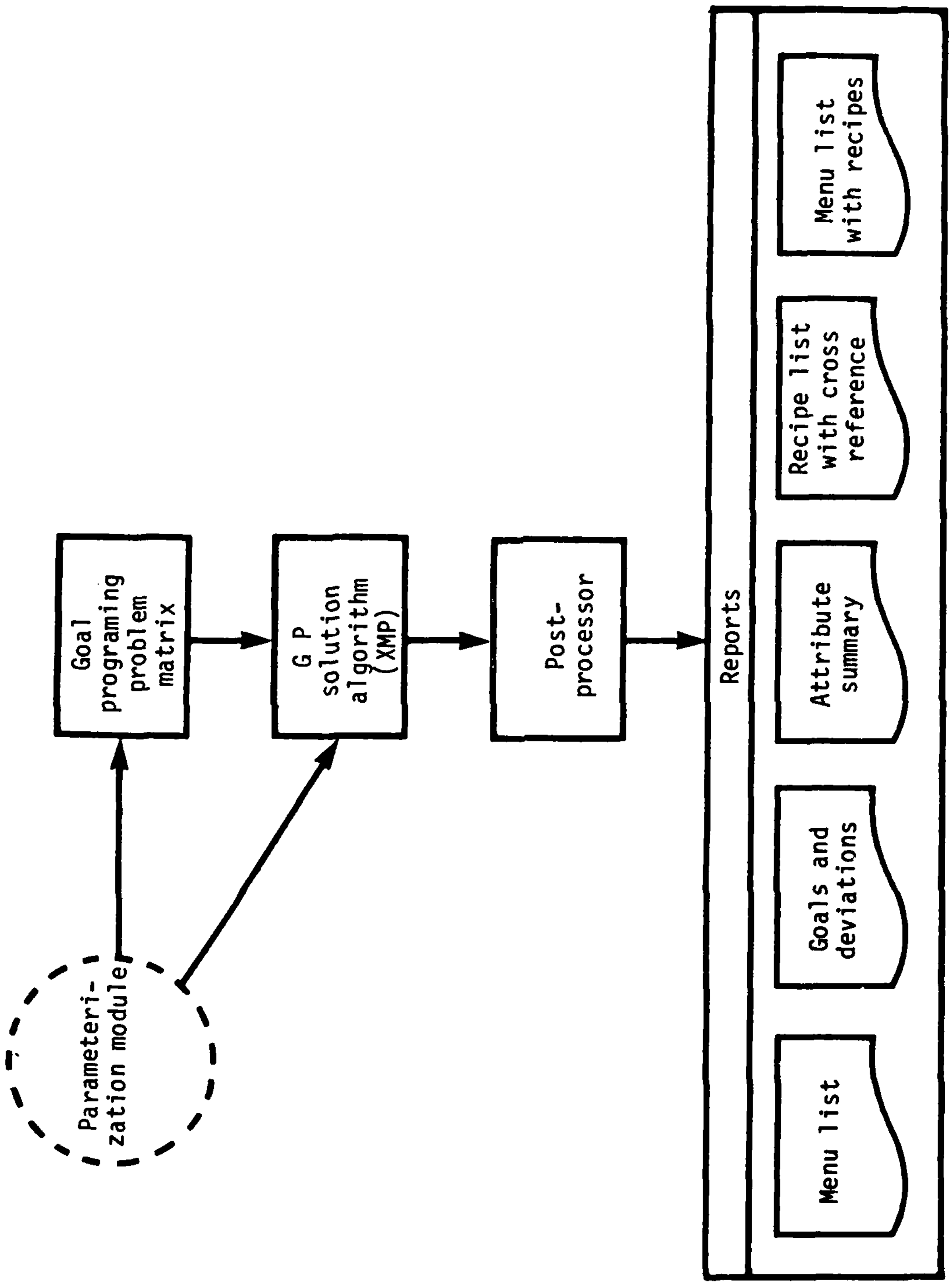


Figure 4-7. Solution Module

```
*************************************************
*                                               *
*     ECONOMETRIC MODEL FOR OPTIMIZING          *
*                                               *
*     TROOP DINING FACILITY OPERATIONS          *
*                                               *
*************************************************


        *****      MENU  PLAN      *****


   THIS MENU PLAN IS BASED ON GOALS THAT ARE
      PRIORITIZED IN THE FOLLOWING ORDER:


          **      LABOR COST
          **      FOOD COST
          **      NUTRITION
          **      ACCEPTABILITY
```

Figure 4-8. Cover Sheet With Priority List

(1) Menu List. As shown in Figure 4-9, the menu list simply lists the menus and the number of times they are served in the cycle.

BREAKFAST		LUNCH		SHORT-ORDER		DINNER	
MENU SELECTED	NUMBER OF SERVING	MENU SELECTED	NUMBER OF SERVING	MENU SELECTED	NUMBER OF SERVING	MENU SELECTED	NUMBER OF SERVING
B-009	4	L-001	2	S-002	2	D-002	2
B-013	4	L-006	2	S-003	2	D-018	2
B-018	4	L-010	2	S-005	2	D-020	2
B-028	4	L-023	2	S-006	2	D-022	2
B-037	4	L-030	2	S-007	2	D-027	2
B-040	4	L-035	2	S-008	2	D-028	2
B-047	4	L-043	2	S-010	2	D-032	2
B-050	4	L-050	2	S-011	2	D-033	2
B-053	4	L-052	2	S-012	2	D-035	2
B-055	2	L-053	2	S-015	2	D-037	2
B-059	4	L-055	2	S-018	2	D-039	2
		L-056	2	S-021	2	D-044	2
		L-068	2	S-022	2	D-045	2
		L-077	2	S-023	2	D-064	2
		L-078	2	S-024	2	D-065	2
		L-083	2	S-025	2	D-075	2
		L-087	2	S-029	2	D-080	2
		L-092	2	S-031	2	D-087	2
		L-097	2	S-032	2	D-092	2
		L-102	2	S-035	2	D-100	2
		L-111	2	S-037	2	D-110	2
11		21		21		21	

Figure 4-9. Menu List

(2) Goals and Deviations. This report is one of the most useful to the menu planner since it displays information concerning the degree to which each of the goals were achieved. This report may indicate that changes should be made to improve the achievement of one goal or another. A sample report is shown at Figure 4-10.

ITEM		GOAL	DEVIATION	ACHIEVEMENT
ACCEPTABILITY (%)				
	BREAKFAST	99.0	-1.9	97.1
	SHORT-ORDER	69.0	-6.3	62.7
	LUNCH	73.0	-13.0	60.0
	DINNER	79.0	-15.1	63.9
FOOD COST ($/INDIVIDUAL)				
	BREAKFAST	.69	-.15	.55
	SHORT-ORDER	.83	-.43	.40
	LUNCH	.56	-.06	.50
	DINNER	1.39	.13	1.52
LABOR (MAN-HOUR/MEAL)				
	BREAKFAST	14.0	5.1	19.1
	SHORT-ORDER	12.0	-.1	11.9
	LUNCH	16.0	7.0	23.0
	DINNER	16.0	5.3	21.3
FAT-CAL RATIO (INDIV/DAY)				
	BREAKFAST	.00	-1.54	-1.54
	SHORT-ORDER	.00	33.79	33.79
	LUNCH	.00	27.53	27.53
	DINNER	.00	27.92	27.92
NUTRIENTS (INDIV/DAY)				
	CALORIES	3200.00	1025.78	4225.78
	PROTEIN (GM)	100.00	63.73	163.73
	FAT	.00	194.22	194.22
	CALCIUM (MG)	800.00	1139.14	1939.14
	IRON (MG)	18.00	20.12	38.12
	VITAMIN A (IU)	5000.00	3082.99	8082.99
	THIAMIN (MG)	1.60	2.43	4.03
	RIBOFLAVIN (MG)	2.00	4.11	6.11
	NIACIN (MG)	21.00	19.72	40.72
	VITAMIN C (MG)	60.00	109.94	169.94

Figure 4-10. Goals and Deviations

(3) Menu Attribute Summary. The menu attribute summary is intended to provide an overview of the menu plan. The average, minimum and maximum for each of the attributes are shown for the corresponding meals. In addition, average breakfast-lunch-dinner and breakfast-short order-dinner combinations are shown. A sample menu attribute summary is shown in Figure 4-11.

	BREAKFAST			SHORT ORDER			LUNCH			DINNER			DAILY	
	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	B-L-D	B-S-D
FOOD COST ($/IND)	.55	.49	.67	.67	.65	.74	1.23	.92	2.43	1.52	1.03	2.46	3.29	2.73
LABOR (MAN-HRS):	19.	18.	20.	12.	10.	13.	22.	21.	24.	21.	19.	22.	62.	52.
ACCEPTABILITY:	97.	97.	98.	63.	61.	67.	59.	42.	73.	64.	51.	75.		
**NUTRIENTS:														
CALORIES:	1142.0	934.9	1537.7	1261.7	1204.2	1346.6	1629.5	1181.0	2308.0	1675.0	1277.9	2308.0	4446.5	4078.7
PROTEIN (GM)	38.8	33.9	45.3	79.9	74.2	93.1	53.4	36.2	83.2	55.7	44.3	83.2	147.8	174.3
FAT (GM)	50.6	43.5	63.7	59.8	56.3	69.5	75.5	49.8	110.1	77.5	50.3	106.5	203.6	188.0
CALCIUM (MG)	738.0	671.0	829.7	421.5	386.9	562.8	711.2	639.1	1001.1	663.8	577.5	755.2	2113.0	1823.3
IRON (MG)	6.1	5.4	7.1	22.2	19.3	25.0	11.0	4.8	23.4	14.3	6.7	34.2	31.4	42.6
VITAMIN A (IU)	2061.	1855.	2334.	651.	515.	971.	5608.	1436.	10810.	3388.	1436.	6917.	11057.	6100.
THIAMIN (MG)	.63	.51	.71	3.72	3.28	4.00	.88	.61	1.49	.82	.61	1.49	2.33	5.17
RIBOFLAVIN (MG)	1.22	1.14	1.32	4.85	4.55	5.04	1.72	1.18	2.82	1.29	1.17	1.93	4.23	7.36
NIACIN (MG)	5.13	3.85	6.50	32.55	29.38	35.28	11.37	7.44	22.17	11.51	7.78	22.17	28.01	49.19
VITAMIN C (MG)	27.13	9.65	51.51	47.64	45.85	55.71	75.83	40.27	116.78	83.89	47.10	128.38	186.85	158.65
NUMBER OF MENUS:		42			42			42			42			

Figure 4-11. Menu Attribute Summary

(4) Recipe List with Cross Reference. This report lists the recipes that would be served under the plan and the menus in which they are included. This information may enable the menu planner to make judgments concerning the frequency of servings for recipes and therefore decide on the suitability of bounding out or bounding in the menus in which those recipes appear. A portion of a sample report is shown at Figure 4-12.

```
**RECIPE C-12       (HOT TEA                   ) IS SERVED IN THE FOLLOWING MENUS:
                    B-010    B-018    B-021    B-026    B-035    B-037    B-039    B-042    B-055    B-060
                    D-004    D-006    D-010    D-013    D-020    D-026    D-027    D-031    D-032    D-051
                    D-063    D-069    D-072    D-081    D-083    D-087    D-088    D-092    D-102    D-109
                    L-021    L-023    L-031    L-032    L-036    L-040    L-046    L-066    L-067    L-071
                    L-076    L-078    L-088    L-095    L-101    L-112
                    TOTAL TIMES SERVED =  107

**RECIPE C-13       (ICED TEA (INSTANT)        ) IS SERVED IN THE FOLLOWING MENUS:
                    L-031    L-110
                    TOTAL TIMES SERVED =    4

**RECIPE C-5        (COFFEE AUTOMATIC URN      ) IS SERVED IN THE FOLLOWING MENUS:
                    B-010    B-018    B-021    B-026    B-035    B-037    B-039    B-042    B-046    B-055
                    B-060    D-004    D-006    D-010    D-013    D-020    D-026    D-027    D-031    D-032
                    D-041    D-051    D-063    D-069    D-072    D-081    D-083    D-087    D-088    D-092
                    D-102    D-109    L-001    L-021    L-023    L-031    L-032    L-036    L-040    L-042
                    L-046    L-056    L-066    L-067    L-071    L-076    L-079    L-086    L-088    L-091
                    L-095    L-101    L-110    L-112
                    TOTAL TIMES SERVED =  12[illegible]

**RECIPE C-6        (FRUIT PUNCH               ) IS SERVED IN THE FOLLOWING MENUS:
                    L-042    L-086    L-091
                    TOTAL TIMES SERVED =    6

**RECIPE C-7        (GRAPEADE                  ) IS SERVED IN THE FOLLOWING MENUS:
                    L-056
                    TOTAL TIMES SERVED =    2

**RECIPE C-8-1      (GRAPE LEMONADE            ) IS SERVED IN THE FOLLOWING MENUS:
                    D-041
                    TOTAL TIMES SERVED =    2

**RECIPE D-1        (BAKING POWDER BISCUITS    ) IS SERVED IN THE FOLLOWING MENUS:
                    D-010    L-046    L-076
                    TOTAL TIMES SERVED =    6

**RECIPE D-13       (QUICK COFFEE CAKE         ) IS SERVED IN THE FOLLOWING MENUS:
                    B-010
                    TOTAL TIMES SERVED =    4

**RECIPE D-13-1     (FRENCH QUICK COFFEE CAKE  ) IS SERVED IN THE FOLLOWING MENUS:
                    B-035
                    TOTAL TIMES SERVED =    4

**RECIPE D-16-1     (PARMESAN CROUTONS         ) IS SERVED IN THE FOLLOWING MENUS:
                    L-001    L-040
                    TOTAL TIMES SERVED =    4

**RECIPE D-16-2     (GARLIC CROUTONS           ) IS SERVED IN THE FOLLOWING MENUS:
                    L-021    L-032    L-071    L-110
                    TOTAL TIMES SERVED =    8

**RECIPE D-18-2     (DOUGHNUTS                 ) IS SERVED IN THE FOLLOWING MENUS:
                    B-021    B-060
                    TOTAL TIMES SERVED =    6

**RECIPE D-22       (FRENCH TOAST              ) IS SERVED IN THE FOLLOWING MENUS:
                    B-010    B-018    B-021    B-026    B-035    B-037    B-039    B-042    B-046    B-055
                    B-060
                    TOTAL TIMES SERVED =   41

**RECIPE D-26-1     (HOT CROSS BUNS            ) IS SERVED IN THE FOLLOWING MENUS:
                    B-055
                    TOTAL TIMES SERVED =    4
```

Figure 4-12. Recipe-menu Cross-reference

(5) Menu List with Associated Recipes. The final report is simply a listing of the menus, showing how often each is to be repeated during the cycle, and the recipes that comprise those menus. A portion of a sample report is shown at Figure 4-13.

```
**MENU NUMBER:  B-010      IS SERVED     4 TIMES.**
    RECIPE:  C-12       ,HOT TEA                          ,KIND :  OTH
    RECIPE:  C-5        ,COFFEE AUTOMATIC URN             ,KIND :  OTH
    RECIPE:  D-13       ,QUICK COFFEE CAKF                ,KIND :  DES
    RECIPE:  D-22       ,FRENCH TOAST                     ,KIND :  ENT
    RECIPE:  E-2-3      ,HOT ROLLED OTTS                  ,KIND :  ENT
    RECIPE:  F-10       ,GRIDDLE FRIED EGGS               ,KIND :  ENT
    RECIPE:  F-11-2     ,CHEESE OMELETTE                  ,KIND :  ENT
    RECIPE:  F-13       ,SCRAMBLED EGGS                   ,KIND :  ENT
    RECIPE:  L-2        ,OVEN FRIED BACON                 ,KIND :  ENT
    RECIPE:  X-114      ,PANCAKES (MIX)                   ,KIND :  ENT
    RECIPE:  X-24       ,CHILLED HONEYDEW MELON           ,KIND :  OTH
    RECIPE:  X-42       ,MAPLE SYRUP                      ,KIND :  OTH
    RECIPE:  X-43       ,JAM/JELLY                        ,KIND :  OTH
    RECIPE:  X-44       ,CEREAL READY-TO-FAT              ,KIND :  ENT
    RECIPE:  X-49       ,BUTTER                           ,KIND :  OTH
    RECIPE:  X-50       ,MILK                             ,KIND :  OTH
    RECIPE:  X-78       ,TOAST                            ,KIND :  OTH
    RECIPE:  X-87       ,CHILLED ORANGE JUICE             ,KIND :  OTH

**MENU NUMBER:  B-018      IS SERVED     3 TIMES.**
    RECIPE:  C-12       ,HOT TEA                          ,KIND :  OTH
    RECIPE:  C-5        ,COFFEE AUTOMATIC URN             ,KIND :  OTH
    RECIPE:  D-22       ,FRENCH TOAST                     ,KIND :  ENT
    RECIPE:  E-2-3      ,HOT ROLLED OTTS                  ,KIND :  ENT
    RECIPE:  F-10       ,GRIDDLE FRIED EGGS               ,KIND :  ENT
    RECIPE:  F-11-2     ,CHEESE OMELETTE                  ,KIND :  ENT
    RECIPE:  F-13       ,SCRAMBLED EGGS                   ,KIND :  ENT
    RECIPE:  J-9        ,STFwED PRUNES                    ,KIND :  DES
    RECIPE:  L-2        ,OVEN FRIED BACON                 ,KIND :  ENT
    RECIPE:  X-114      ,PANCAKES (MIX)                   ,KIND :  ENT
    RECIPE:  X-42       ,MAPLE SYRUP                      ,KIND :  OTH
    RECIPE:  X-43       ,JAM/JELLY                        ,KIND :  OTH
    RECIPE:  X-44       ,CEREAL READY-TO-FAT              ,KIND :  ENT
    RECIPE:  X-49       ,BUTTER                           ,KIND :  OTH
    RECIPE:  X-50       ,MILK                             ,KIND :  OTH
    RECIPE:  X-78       ,TOAST                            ,KIND :  OTH
    RECIPE:  X-87       ,CHILLED ORANGE JUICE             ,KIND :  OTH

**MENU NUMBER:  B-021      IS SERVED     2 TIMES.**
    RECIPE:  C-12       ,HOT TEA                          ,KIND :  OTH
    RECIPE:  C-5        ,COFFEE AUTOMATIC URN             ,KIND :  OTH
    RECIPE:  D-10-2     ,DOUGHNUTS                        ,KIND :  DES
    RECIPE:  D-22       ,FRENCH TOAST                     ,KIND :  ENT
    RECIPE:  F-10       ,GRIDDLE FRIED EGGS               ,KIND :  ENT
    RECIPE:  F-11-2     ,CHEESE OMELETTE                  ,KIND :  ENT
    RECIPE:  F-13       ,SCRAMBLED EGGS                   ,KIND :  ENT
    RECIPE:  L-3        ,GRILLED BACON                    ,KIND :  ENT
    RECIPE:  L-65-3     ,GRILLED HAM SLICES               ,KIND :  ENT
    RECIPE:  Q-47       ,HOME FRIED POTATOES              ,KIND :  STA
    RECIPE:  X-114      ,PANCAKES (MIX)                   ,KIND :  ENT
    RECIPE:  X-42       ,MAPLE SYRUP                      ,KIND :  OTH
    RECIPE:  X-43       ,JAM/JELLY                        ,KIND :  OTH
    RECIPE:  X-44       ,CEREAL READY-TO-FAT              ,KIND :  ENT
    RECIPE:  X-49       ,BUTTER                           ,KIND :  OTH
    RECIPE:  X-50       ,MILK                             ,KIND :  OTH
    RECIPE:  X-78       ,TOAST                            ,KIND :  OTH
    RECIPE:  X-6        ,GRAPEFRUIT HALF                  ,KIND :  OTH
    RECIPE:  X-80       ,CHILLED TOMATU JUICE             ,KIND :  OTH

**MENU NUMBER:  B-026      IS SERVED     4 TIMES.**
    RECIPE:  C-12       ,HOT TEA                          ,KIND :  OTH
    RECIPE:  C-5        ,COFFEE AUTOMATIC URN             ,KIND :  OTH
    RECIPE:  D-22       ,FRENCH TOAST                     ,KIND :  ENT
    RECIPE:  F-10       ,GRIDDLE FRIED EGGS               ,KIND :  ENT
    RECIPE:  F-11-2     ,CHEESE OMELETTE                  ,KIND :  ENT
    RECIPE:  F-13       ,SCRAMBLED EGGS                   ,KIND :  ENT
    RECIPE:  L-3        ,GRILLED BACON                    ,KIND :  ENT
    RECIPE:  L-30       ,CRMJ GROUND BEEF                 ,KIND :  ENT
    RECIPE:  X-114      ,PANCAKES (MIX)                   ,KIND :  ENT
    RECIPE:  X-42       ,MAPLE SYRUP                      ,KIND :  OTH
    RECIPE:  X-43       ,JAM/JELLY                        ,KIND :  OTH
```

Figure 4-13. Menu List with Associated Recipes

4-4. SUMMARY. As mentioned, the model design is intended to correspond to the typical sequence of operation in menu planning. The maintenance of data files as performed by the data module is a continual process, and therefore the data module will often be used independent of the rest of the model. The link between the data module and the rest of the model is established through the menu attribute file. Therefore, while the modules may be operated independently, the Parameterization Module and Solution Module are dependent on the validity of data contained in the menu attribute file, and, in turn, the recipe attribute file and the menu component file.

CHAPTER 5

MATHEMATICAL PROGRAMING ALGORITHMS

5-1. INTRODUCTION. The development of mathematical programing has been ranked as one of the most important scientific advances of the mid-20th century. It has had an impact on virtually every aspect of industrialized society. Mathematical programing typically deals with the problem of allocating limited resources among competing activities in the best possible way. The allocation problem arises in menu planning when one considers the best use of available budgeting and labor resources in the design of a menu plan. Two factors have contributed to the development and popularity of mathematical programing. The first of these is the increased scarcity of resources, and the second is the development of modern computers by which problems involving thousands of variables and constraints may be quickly and easily solved. This chapter is not intended to give a detailed description of mathematical programing or the solution algorithms, but simply to introduce the concepts as they were applied to this study. A list of references that deal with the subjects of linear programing and goal programing may be found in Appendix C.

5-2. LINEAR PROGRAMING (LP). Linear programing uses a mathematical model to describe the problem. All the mathematical functions in the model, including the objective function and constraint rows, must be linear. LP models consist of a single objective function which is to be maximized or minimized subject to a set of constraint type equations. The LP problem can best be visualized in geometric terms. The n variables define an n-dimensional space. The set of constraints limits the n-dimensional space to a region known as the feasible region in which all possible solutions must exist. The function to be optimized is a linear function of the variables and corresponds to a family of hyperplanes. Some of the hyperplanes in this family cut through the feasible region, while other do not. As long as the feasible region is not unbounded, there are two limiting hyperplanes, one corresponding to the largest value of the function for which the hyperplane just touches the feasible region, and one corresponding to the smallest value which just touches. For most orientations of the family of planes, the two limiting planes touch the surface of the feasible region at just one point known as a corner-point feasible solution resulting in a unique optimum solution. The general solution procedure used in solving the problem is called the simplex method. The simplex procedure can be summarized as shown in Table 5-1. A refinement of the original simplex method is known as the two-phase method. The first phase consists of determining a corner-point feasible solution from which to begin and assuring that an optimal feasible solution exists. The second phase involves the use of the normal simplex rules to achieve the optimal solution. With a problem that is structured in such a way that a starting feasible solution is known, the first phase may be eliminated.

Table 5-1. Outline of the Simplex Method

Initialization Step. Start at a corner-point feasible solution.
Iterative Step. Move to an adjacent corner-point feasible solution (repeat this step as often as needed).
Stopping Rule. Stop when the current corner-point feasible solution is better than all its adjacent corner-point feasible solutions. It is an optimal solution.

Source: Operations Research, Hillier and Lieberman.

5-3. GOAL PROGRAMING (GP). Goal programing may be discussed in terms of a concept known as "satisficing" that was introduced by H. A. Simon. Simon declared that most human decisionmaking, whether organizational or individual, is concerned with the discovery and selection of satisfactory alternatives; only in exceptional cases is it concerned with the discovery and selection of "optimal" alternatives. In LP the single criterion is optimized directly, whereas in keeping with the idea of "satisficing" GP is concerned with minimizing the deviation from the problem goals. These deviations are minimized based on the relative priority assigned to them. There are two basic approaches to solving GP problems. One involves the use of a modified simplex or multiphase method while the other involves the use of a procedure known as sequential linear goal programing (SLGP).

a. Multiphase Simplex Method. Both the multiphase method and SLGP are based on attempts to satisfy the highest priority goal first, then the second, and on down to the lowest priority goal. The multiphase approach involves the use of an augmented simplex tableau. The multiphase approach is highly efficient, but no computer algorithms have been developed for general use that are capable of solving problems of any substantial size.

b. Sequential Linear Goal Programing (SLGP). SLGP involves the solving of a series of LP problems. Since the GP problem is one of minimizing the deviations from the goals that are associated with successive priority levels, it may easily be restructured as a series of LP problems. The first LP problem is to minimize a function of deviation variables associated with the first priority goals. The solution to this problem thus becomes a constraint for the next problem, which is to minimize a function of deviation variables associated with the second priority goals. This procedure is continued for all successive priority levels. The effect of this procedure is that the goals associated with a particular priority level are satisfied as "close as possible" without reducing the achievement of any higher priority goals. The advantage of using SLGP is that there are many LP algorithms that can be adapted to efficiently perform the procedure.

5-4. XMP. XMP is a structured library of subroutines for experimental mathematical programing. XMP was developed under grant by Professor Roy E. Marsten of the University of Arizona. An introduction to XMP is contained in Appendix E, and a thorough discussion of the library was published in the December 1981 issue of ACM Transactions on Mathematical Software[17]. XMP is a fairly complex package that cannot be adequately detailed within the scope of this report; however, it basically consists of a set of subroutines that performs the various functions involved in the simplex method. This study marks the first adaptation of XMP to goal programing.

5-5. SEQUENTIAL LINEAR GOAL PROGRAMING VIA XMP. The use of XMP for solving goal programing problems involved the development of several subroutines that interface with the existing XMP subroutines. No modifications were made to existing XMP subroutines except that a demonstration program included with the library was modified and expanded for the purposes of this study. In addition, the XMAPS routine was changed to allow for the data storage requirements of the menu planning problems.

a. Setting Up the Problem Matrix. A major part of using an LP package to perform SLGP is the generation of the problem matrix. Obviously it is possible to set up a distinct LP problem for each priority level; however, this would be a slow process involving unnecessary repetition. Instead, the matrix generator developed under this study sets up the entire problem matrix in one step. This means that the problem matrix contains one objective function for each priority level (five total: structural, acceptability, food cost, labor cost, nutrition) and all the constraints (objective functions, in GP terminology). All the objective functions are initially declared as nonrestraining rows, and only those constraints associated with the first priority are identified as equality type rows. All other constraints are initially nonrestraining rows.

b. SLGP Solution Procedure. Given the starting problem matrix, the first step in solving the problem is to designate the row that becomes the LP objective function. As explained in Chapter 3, the first priority always consists of the set of rigid constraints; therefore, the first objective function is declared to be the one that is a function of the deviation variables associated with those constraints. Since the constraints associated with the first priority problem are the only constraining rows, the objective function is simply minimized subject to those constraints. All other rows play no part in the solution at this point. Since the first priority goals must be met as rigid constraints, the minimum value of the objective function for the first priority problem must be zero. Once the first priority problem is solved, that value of the objective function becomes a constraint for successive priority levels. This is accomplished by declaring the old objective function to be an equality type row with a righthand side value equal to its minimum value, zero, in the first LP problem. The rows associated with the second priority level are changed to equality type rows, and the objective function associated with those rows is declared as the new function that is to be minimized. This process is continued for each successive priority level and is summarized in Table 5-2.

Table 5-2. SLGP Algorithm via XMP

Step	Procedure
1	Generate the problem matrix with only the constraints for the first priority objectives as equality (E-type) rows.
2	Read the problem matrix in its starting form.
3	Designate the objective row (name of objective row read from priority file).
4	Solve first priority problem.
5	Read new objective row name, and names of associated equality constraint rows.
6	Change objective function to the new objective row.
7	Change the old objective row to an E-type constraint.
8	Change the associated rows to E-type constraints.
9	Set the RHS of the old objective row equal to the last objective value.
10	Solve the new problem starting with the existing basis.
11	Continue repeating steps 5 through 10 until all priorities have been solved.

CHAPTER 6

ANALYSIS AND ASSESSMENT

6-1. INTRODUCTION. As mentioned in Chapter 1, the purpose of this study was to develop the methodology and associated models which may be used to guide the analytical preparation of the Army Master Menu. This chapter presents an analysis of that methodology and an assessment of the capabilities of the Master Menu Model.

6-2. OBJECTIVES. An analysis of the methodology must be conducted within the framework of the study objectives. A review of those objectives along with an assessment of the degree to which they were achieved is necessary before discussing the sample menu plans.

a. The first objective was to identify the menu planning parameters. The menu planning parameters may be grouped into three categories: data elements, attributes, and goals.

(1) Data Elements. There are three data elements associated with a menu plan. They are food items, recipes, and menus. The decision to use menus as the basic data element of the optimization process may at first glance appear to be a limitation of the methodology. In fact, one of the problems with the existing system has been the absence of a consistent approach to evaluating the relative worth of menus. The methodological approach of this study was based on providing that consistency. While the idea of using recipes, or even food items as the decision variables might seem pleasing, to do so would actually limit the menu planners from playing any role in the decision process.

(2) Attributes. There were four attributes considered in this study: acceptability, food cost, labor cost, and nutrition. As required by the study directive, the data provided by TSA included all four attributes of each recipe, including 10 nutrients.

(a) Acceptability is the attribute that seems to receive the most attention. The reason for this is that acceptability is the most difficult attribute to quantify. The acceptability factor for each recipe represents the percentage of individuals who select that recipe when it is placed on the serving line. These factors were determined through empirical data analysis based on serving the recipes with a wide array of accompanying recipes. In light of that, it is not unreasonable to treat the acceptability factor as the probability that a particular recipe is preferred to another recipe which is selected at random. Intuitively, it is clear that a recipe such as fried chicken is much more acceptable when the other entree is liver than it would be if the other entree were grilled steak, but that does not mean that there must necessarily be separate acceptability data for all possible combinations of recipes. Instead, the effect of such pairings on the acceptability of the overall menu, and on the relative consumptions of recipes is adequately reflected through the analytical process involved in the generation of the menu attribute file. In the example just cited, when chicken is served with steak, the acceptability of the entree portion of the meal is 96.5 percent, and 42 percent of the diners are expected to select chicken. When chicken is served with liver, the acceptability of the entree is reduced to 79 percent but the number of diners expected to select chicken jumps up to 62 percent. These calculations, based on the procedure outlined in Chapter 3, are shown in Table 6-1. It should be clear that this process produces some needed consistency in the evaluation of menu acceptability and consumption rates.

Table 6-1. Acceptability of Steak and Chicken versus Liver and Chicken

Recipe	Acceptability	Probability of rejection
Fried chicken	65%	.35
Grilled steak	90%	.1
Liver w/onions	40%	.6

Chicken w/steak:

$$\text{Entree acceptability} = 1-(.35)(.1) = .965 \text{ or } 96.5\%$$

$$\text{Percent expected to eat chicken} = \frac{65}{155} = 42\%$$

Chicken w/liver:

$$\text{Entree acceptability} = 1-(.35)(.6) = .79 \text{ or } 79\%$$

$$\text{Percent expected to eat chicken} = \frac{65}{105} = 62\%$$

(b) Food cost is a measure of how many dollars are needed to purchase the raw foods required by a menu plan. An evaluation of expected consumption as outlined in the previous paragraph clears the way for a consistent approach to determining the relative cost of menus.

(c) Labor cost is the simplest attribute to deal with because of the assumption that a fixed labor cost is associated with 100 or fewer servings of any recipe. In most cases this is a valid assumption, however in the case of recipes such as salmon cakes that must be prepared in individual servings, it requires more time to prepare 100 servings than it does to prepare 60. In general, the data concerning labor costs could be improved.

(d) Nutrition is a very complex subject in which concepts are changing on almost a daily basis. The Army regulation on the subject of nutritional standards, AR 40-25, is currently being revised. Although a draft copy of the revised regulation was received by the study team, no attempt was made to incorporate the revised requirements into the model. This does not imply that the new requirements cannot be handled by the model, but that the model was designed in consideration of existing requirements. Procedures for incorporating new requirements will be discussed in Chapter 7. For the present, since nutritional benefit is derived only from the food that is actually consumed, the nutritional benefit of a menu is derived in the same way that the food cost of a menu is derived--by the expected consumption of individual recipes. There is another aspect to nutrition that cannot be reflected as a function of acceptability, and that is the increased emphasis on nutritional education. As the individual diner becomes more knowledgeable about the nutritional benefit of certain foods, presumably he or she will be more likely to accept nutritionally beneficial foods. It is therefore important that TSA continue evaluating the acceptance of recipes so that these trends are reflected in the input data.

(3) Goals. In keeping with the concepts of goal programing, menu planning goals are viewed as being aspiration levels. A goal is a level of achievement to which one aspires, even though it may be unattainable. It is generally a good idea to set attainable goals whenever possible so that lower priority goals are not unreasonably restricted. Goals which must be met, such as those associated with rigid constraints, should be placed in the first priority.

(a) Structural Goals. The only rigid constraints in the mathematical model are the structural equations, which have the effect of requiring that there be one meal of each type for every day of the menu cycle. The goal for these equations is the cycle length in days and may vary from 1 day to 366 days or more. The normal goal is 42 days.

(b) Acceptability. The acceptability goals are distinct for each meal since the structure of the meal influences the level of acceptability. Since breakfast menus are comprised of several entrees and there is little chance of rejecting all of them, the average acceptability of a breakfast meal is very high. As a result, the acceptability goal should also be very high. For the sample data used in the model development, a goal of 99 percent was used for breakfast, 69 percent for short order, 73 percent for lunch, and 79 percent for dinner. In each case, the goal of the mathematical model (the RHS) is the menu goal times the number of days in the cycle. As an example, if the goal is to achieve 79 percent acceptability for dinner meals in a 42-day cycle, then the RHS in the mathematical model for dinner acceptability is 79 x 42 = 3,318. The parameterization module takes care of setting the RHS and the menu planner simply needs to enter the acceptability goals for each meal. The best way to select goals is to use the acceptability factor for any highly acceptable menu of each meal type. This implies that the aspiration is to have all menus of that meal type be at least as acceptable.

(c) Food Cost. The food cost goals are simply a percentage of the BDFA: 20 percent for breakfast, 24 percent for short order, 16 percent for lunch, and 40 percent for dinner. Once again, the parameterization module sets the RHS value. As an example, if $3.47 is the BDFA, then the dinner food cost goal is the BDFA times the meal percentage factor times the total number of diners times the length of the menu cycle in days:

$$\$3.47 \times 40\% \times 100 \text{ diners} \times 42 \text{ days} = \$5{,}829.60$$

Since the BDFA is the amount of subsistence to which the soldier is entitled, the goal is to be met as closely as possible. The goal is not to hold down food costs, but to spend the BDFA.

(d) Labor Cost. In the case of labor, the aspiration is to hold down labor manhours. The labor goals are somewhat arbitrary except that TSA has indicated a desire to dedicate no more than 14 manhours to breakfast, 12 to short order, 16 to lunch and 16 to dinner.

(e) Nutrition. Nutritional goals are based on the recommended daily allowances of 10 nutrients as specified in AR 40-25. These recommendations are estimates of the daily average quantity of nutrients which should be consumed to meet the physiological needs of most healthy military personnel under normal conditions. These recommendations are not amounts necessarily required by an individual, but are goals at which to aim in meeting nutritional needs of groups or individuals. Since each daily nutritional goal is multiplied times the number of diners and the number of days in the cycle, the implication is that the goals are to be met over the length of the cycle and not necessarily on a daily basis. Calories and fats are given special attention due to the recent emphasis on weight control and the concern that some fats, in sufficient quantities, may be harmful and may lead to increased risk of heart and blood vessel disease. For all nutrients except calories, the nutritional goals are levels below which the nutrients should not drop, and the aspiration is to achieve at least a certain amount of each nutrient per individual per day. With calories, the aspiration is to meet the recommended allowance. In addition, the desirable proportion of total calorie intake from fat sources is less than 40 percent. There are two types of equations in the math model that deal with fats. One is concerned with the fat/calorie ratio just mentioned, and the other requires that a certain level of fats be included, since fats are important in the diet to provide essential fatty acids, increase palatability, and give a feeling of satiety. Since no specific minimum for fats is given in AR 40-25, a goal of zero was used. The effect is that the only factor influencing the amount of fats is the fat/calorie ratio. A specific goal for fats may be entered if desired. The draft revision of AR 40-25 imposes a standard of 160 grams of fat.

(f) It is necessary to remember that regardless of what goals are entered, the actual level of achievement for each of the goals is displayed in the report on goals and deviations. Changes may be made to the menu planning goals in consideration of the actual levels of achievement. In some cases this may be desirable when reprioritizing goals, or in order to assure that subsequent priority levels are not overly restricted.

b. The second objective of this study was to develop a methodology which is capable of selectively achieving the goals set for food cost, labor, acceptability, and nutritional value. It might be said that this is the main objective of the study, and it was clearly achieved. The goal programing methodology is centered around the idea of goal achievement, and the model incorporates the ability to interactively change the various goals and selectively reprioritize them. The process of analyzing the capabilities of the model was limited somewhat by the inadequacies of the sample data set. There was a contradiction built into the process because the goals that were used may have been more realistic than the data set, and as a result some of the goals, such as those for labor, were virtually unachievable. In addition, the food cost goal was based on a recent BDFA while the recipe cost data was at least 2 years old. In light of the inadequacies of the sample data set, the important standard by which to measure is not actual goal achievement, but whether consistent progress was made toward each goal as the priority of that goal attainment was raised. In other words, even though a goal may be unattainable within the limits of the data set, progress may be made toward achieving that goal simply by raising its priority.

c. Figures 6-1 through 6-4 illustrate that such is the case. There are four priority levels excluding the structural constraints, one for each of the four attributes: acceptability, food cost, labor cost, and nutrition. There are 24 possible ways in which the achievement of goals for those four attributes may be prioritized (4!=24). A series of menu plans was generated in which the only change was the priority order. Figures 6-1 through 6-4 indicate the average goal achievement at each priority level. As an example, there were six solutions in which food cost was the second priority. The average breakfast food cost of those six solutions was $0.55. In the case of nutrition, only a single nutrient, calories is shown. The dashed lines in each figure represent the goals. In almost all cases, the goals were virtually unattainable, and therefore the model became very restricted at the lower priorities. As a result, there is no appreciable difference in goal achievement for any of the attributes once their priority is lowered below the second priority level. This may give the impression that there is no difference whether an attribute is assigned to the third or fourth priority level. In fact, depending on the data, the goals, and what has gone on in the previous priorities, there may be a significant difference in reordering priorities below the second level. Of course, the menu planner is given the flexibility necessary to evaluate the effect of reprioritizing the goals.

d. The final objective was to apply the methodology to the design of a sample 42-day Master Menu based on serving 100 individuals in accordance with the policies and procedures of the Army Ration Credit System (ARCS). As explained in the previous paragraph, a number of sample menus have been designed. Additional sample menu plans will be presented later in this chapter.

e. Observation. While all study objectives have been met, it should be clear that the ability to design good menus is dependent to a large extent on the validity of the data set. The methodology may be reduced in its simplest terms to one of selecting the best subset of menus from a larger set of menus. If the larger set of menus included an infinite variety of menus in terms of the four attributes, then the menu planner could be certain that no possibilities had been excluded. Of course, this is not possible, but it is possible to offer a wide choice of menus. In addition, the validity of the data and the goals is of paramount importance. If the menu planner sets unreasonably high goals at a high priority, then the other menu planning goals may suffer. To use the menu planning model effectively, the planner must have an understanding of the data set, and a clear picture of what may be expected to happen when various parameters are changed. Paragraph 6-3 concerning sample menu plans is intended to provide more information on the effect of parameter changes.

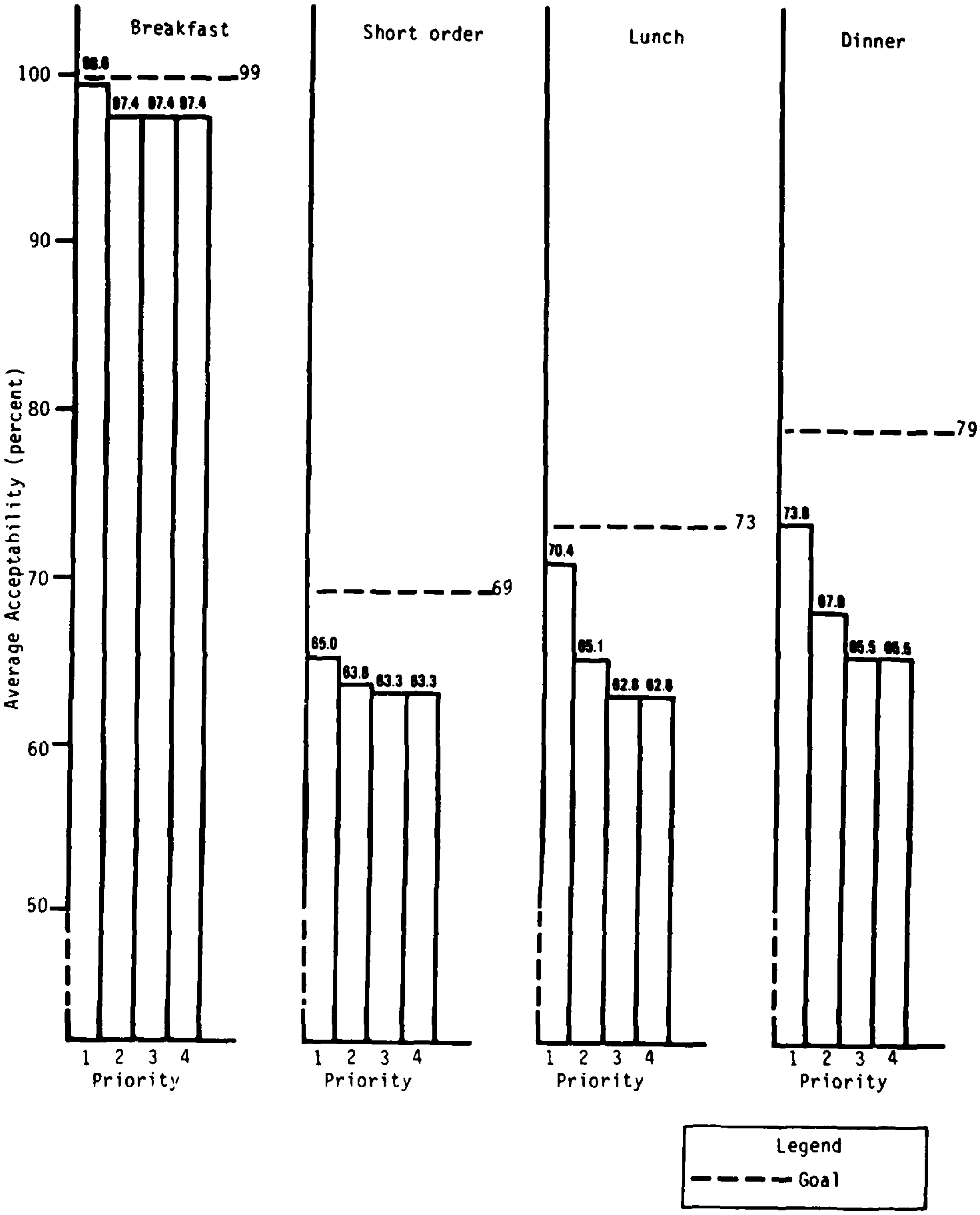


Figure 6-1. Average Goal Achievement - Acceptability

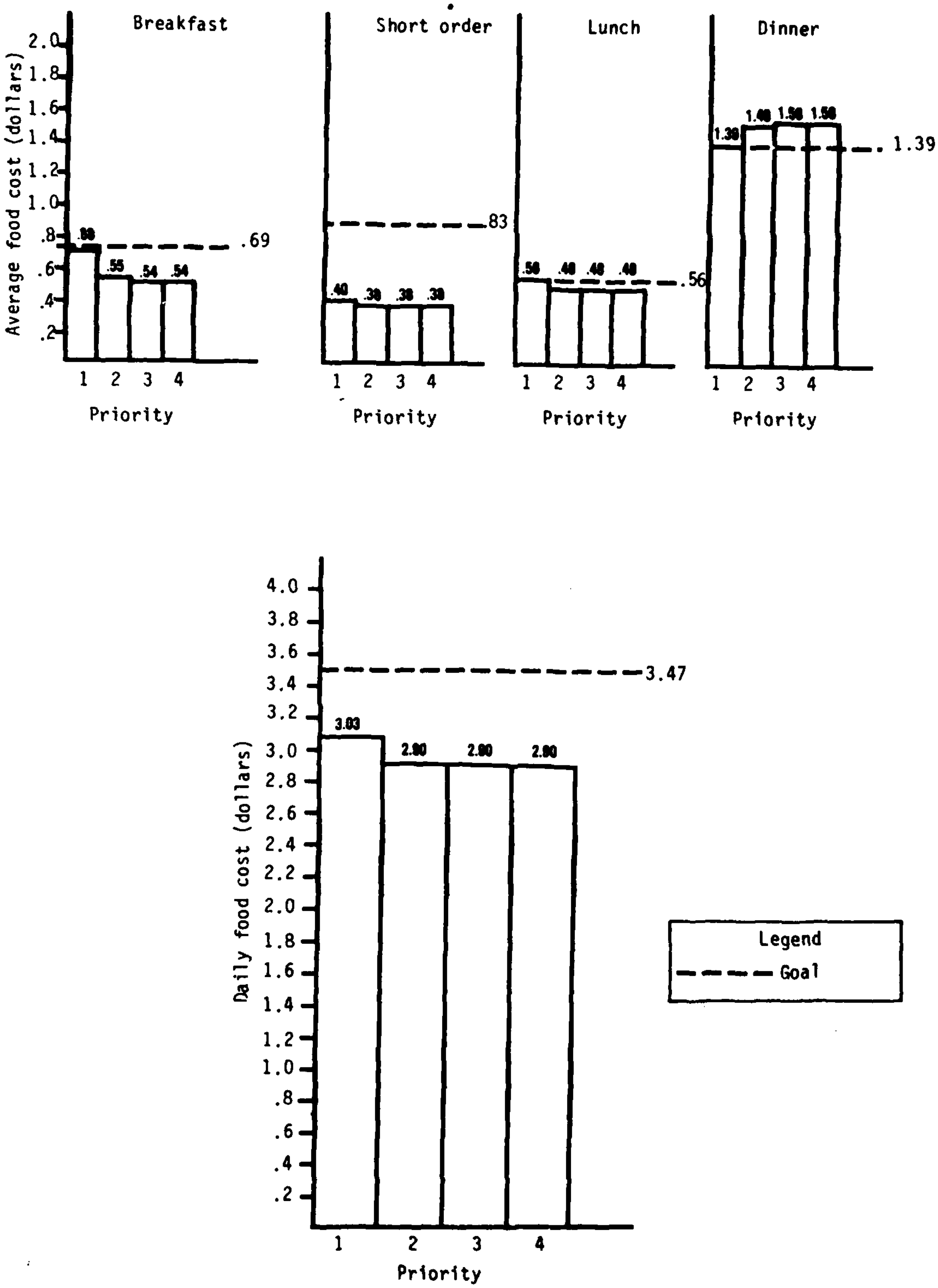


Figure 6-2. Average Goal Achievement - Food Cost

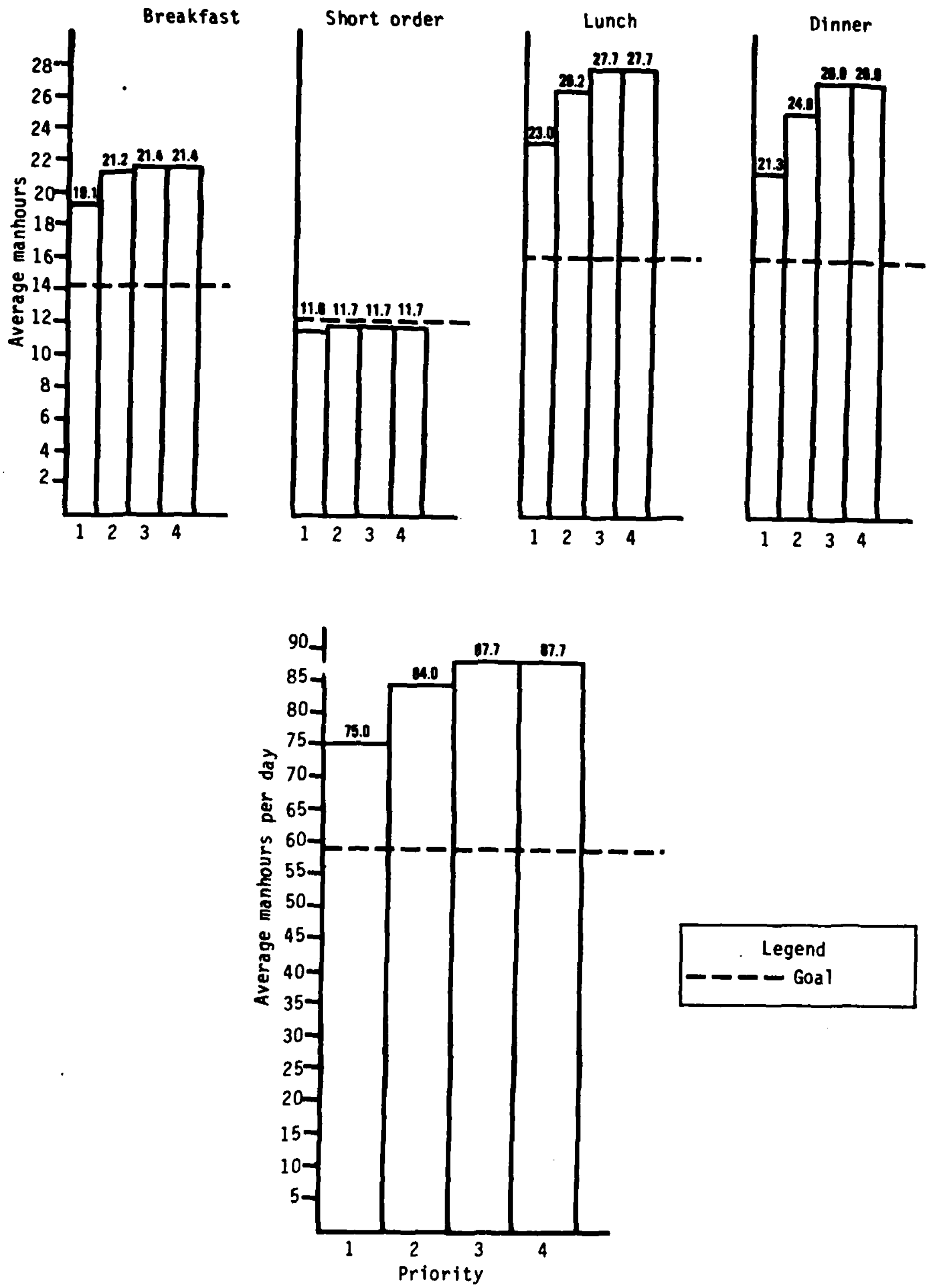


Figure 6-3. Average Goal Achievement - Labor

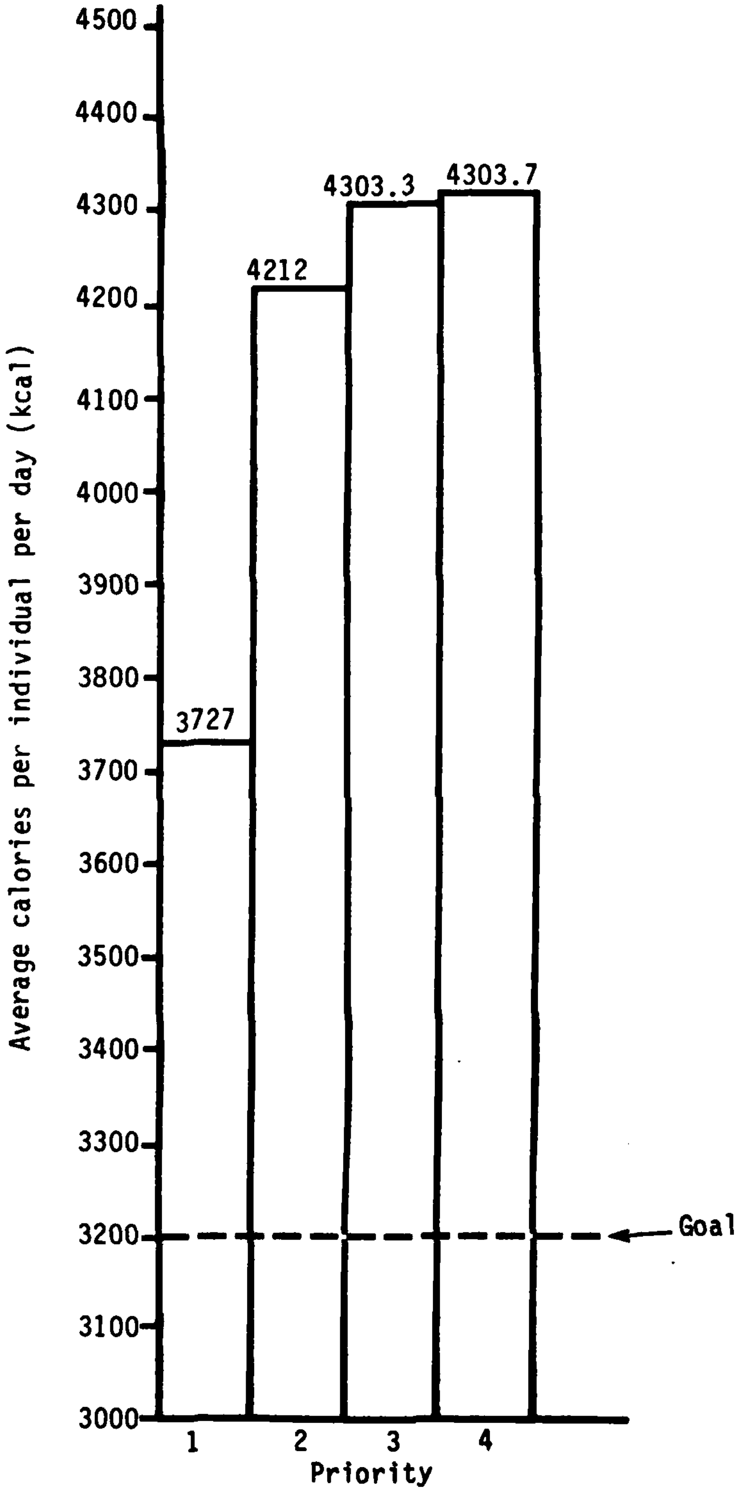


Figure 6-4. Average Goal Achievement - Calories

6-3. SAMPLE MENU PLANS. This paragraph is concerned with the presentation of sample menu plans in the context of the sample data set and the procedures taken to generate those plans.

a. Sample Data Set. As mentioned before, it is necessary to have a clear understanding of the data set; therefore, it is necessary to provide some information concerning the sample data set provided by TSA before presenting sample menu plans.

(1) Menu Attribute Summary. A summary of the menu attributes from the TSA data is shown in Table 6-2. This includes 66 breakfast, 37 short order, 112 lunch, and 110 dinner menus. For each type of menu, the minimum, maximum, and average values of each attribute are shown. In addition, the breakfast-lunch-dinner (B-L-D), and breakfast-short order-dinner (B-S-D) daily averages are shown for each of the attributes. Several conclusions may be drawn about possible menu plans from this information. One is that the labor goals of 14, 16, and 16 manhours, provided by TSA, for breakfast, lunch, and dinner are unrealistic for this data set. For the menu planner who is interested in producing a valid menu plan, the choices are to: reexamine the data, include more menus that are less labor intensive, or possibly lower the goals. In order to illustrate the process, goals of 19, 12, 24, and 24 manhours for the breakfast, short order, lunch, and dinner menus may be more reasonable. The food cost goal is also unattainable, but the option of changing the BDFA is not usually available to the menu planner. In this case, the data set should probably be updated with current prices. The BDFA of $3.47 was current at the time this study began. Again, for the sake of illustration, a BDFA of $3.00 is more in keeping with the data set. The goals that were previously shown for acceptability corresponded to the most acceptable menus of each type. Instead, a reasonable goal for breakfast might be 98 percent, while short order, lunch, and dinner might have goals of 65 percent, 68 percent, and 70 percent, respectively. These goals should not be interpreted to mean that the menu planner wants only 70 percent of the diners to accept a dinner menu. The acceptability factors reflect the structure of the meals and are measures by which various menus may be compared and are not absolute measures of acceptability. A simple way to raise the acceptability of a meal is to include the choice of another entree, but there is a resultant increase in labor cost. Finally, the nutritional data indicates that the data set includes a lot of menus high in calories and fats, so a goal of 3200 calories may be unreasonably restrictive. Instead, a goal of 3800 as recommended in the revision to AR 40-25 may be more appropriate.

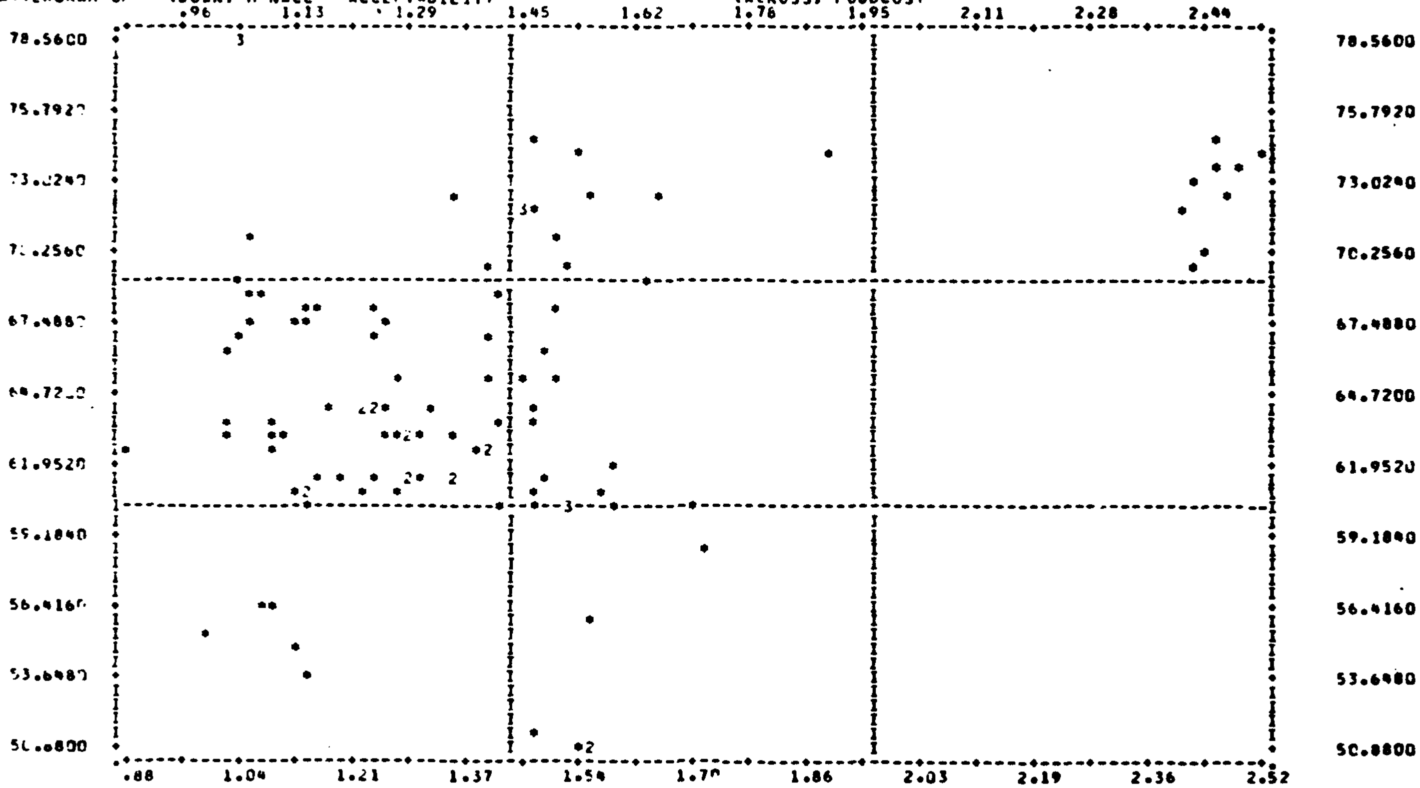
Table 6-2. Menu Attribute Summary

	BREAKFAST			SHORT ORDER			LUNCH			DINNER			DAILY	
	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	B-L-D	B-S-D
FOOD COST ($):	57.	48.	76.	64.	54.	74.	121.	82.	243.	141.	88.	252.	319.	263.
LABOR (MAN-HRS):	21.	19.	27.	12.	10.	13.	26.	21.	34.	26.	19.	35.	74.	59.
ACCEPTABILITY:	96.	96.	99.	63.	55.	69.	64.	42.	73.	65.	51.	79.		
**NUTRIENTS:														
CALORIES:	1226.[illegible]	934.9	1570.5	123[illegible].7	1[illegible]33.7	1346.6	1639.6	1181.0	2699.3	1685.9	1240.0	2398.0	4552.3	4143.4
PROTEIN (GM)	47.2	[illegible].9	74.3	77.4	59.6	93.1	55.3	35.5	95.9	57.9	42.9	83.2	155.4	177.4
FAT (GM)	54.[illegible]	43.5	69.7	58.3	48.2	69.5	72.3	49.8	133.9	79.5	44.3	124.2	205.8	191.8
CALCIUM (MG)	739.7	66[illegible].3	862.7	406.6	345.5	562.6	725.2	578.3	1181.9	694.0	574.2	1015.4	2158.9	1840.4
IRON (MG)	6.6	[illegible]	18.5	21.4	14.9	26.7	11.5	4.4	34.5	10.5	5.6	34.5	28.6	38.5
VITAMIN A (IU)	2371.	172[illegible].	4629.	604.	477.	1225.	4576.	1436.	10810.	4290.	1436.	10671.	10938.	7025.
THIAMIN (MG)	.76	.46	3.46	3.64	2.97	4.19	.94	.61	2.64	.92	.55	1.60	2.62	5.32
RIBOFLAVIN (MG)	1.29	1.11	2.13	4.79	4.26	5.14	1.74	1.07	4.22	1.63	1.15	4.60	4.65	7.70
NIACIN (MG)	5.84	3.7[illegible]	10.29	31.76	24.81	35.83	11.63	7.14	26.96	11.92	7.78	22.17	29.39	49.51
VITAMIN C (MG)	24.53	6.24	54.[illegible]5	47.44	45.65	55.71	77.32	26.85	144.46	79.27	26.08	140.87	181.17	151.29
NUMBER OF MENUS:	66			37			112			110				

(2) Correlation of Menu Attributes. A simple examination of the range of the menu attributes may not provide the menu planner with all the necessary information. Some knowledge of how the attributes are correlated may be desirable. As an example, it might be expected that menus high in acceptability would cost more. The scattergram shown in Figure 6-5 illustrates that this is not necessarily so for the sample data set. The vertical scale is acceptability while the horizontal is food cost. As can be seen, there is little correlation between the two attributes for the dinner menus. A correlation coefficient (r) of .31 is low when 1.0 indicates perfect correlation. In fact, the only relatively strong correlation of attributes seems to be between food cost and calories. This is shown by another scattergram in Figure 6-6. A correlation coefficient of .7 implies that costlier meals are generally higher in calorie content. The purpose in presenting the scattergrams is not to imply that the menu planner needs a complete statistical breakdown of the data set, but to show that false assumptions about the data set may lead to unexpected results.

b. Sample Procedures. Given that the menu planner has satisfactory information concerning the data set and has settled on the goals, as shown in Figure 6-7, it is necessary to establish upper bounds when generating the problem matrix, as shown in Figure 6-8. In this case, no breakfast menu may be repeated in its entirety more than 4 times, while no short order, lunch, or dinner menu may be repeated more than twice in a 42-day cycle. Once the priority order has been established, as shown in Figure 6-9, a menu plan may be produced.

```
CORRELATION OF MENU ATTRIBUTES BY PAIRS
ACCEPTABILITY VERSUS FOOD COST (DINNER)
FILE   MENUDATA (CREATION DATE = 06/21/82)
SCATTERGRAM OF   (DOWN) MENACC   ACCEPTABILITY                    (ACROSS) FOODCOST
```

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CORRELATION OF MENU ATTRIBUTES BY PAIRS
ACCEPTABILITY VERSUS FOOD COST (DINNER)
STATISTICS..
```

CORRELATION (R)-	.31016	R SQUARED -	.09620	SIGNIFICANCE -	.00049
STD ERR OF EST -	5.69399	INTERCEPT (A) -	57.88930	SLOPE (B) -	5.02685
PLOTTED VALUES -	110	EXCLUDED VALUES-	0	MISSING VALUES -	0

'********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

Figure 6-5. Correlation of Acceptability vs Food Cost

AD-A122 635 ECONOMETRIC MODEL FOR OPTIMIZING TROOP DINING FACILITY OPERATIONS (THE ARMY MASTER MENU STUDY)(U) ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD A C MANGUSO 2/2

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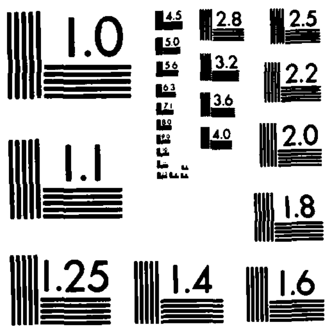

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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CORRELATION OF MENU ATTRIBUTES BY PAIRS
FOOD COST VERSUS CALORIES (ALL MEALS)
FILE   MENUDATA (CREATION DATE = 06/21/82)
SCATTERGRAM OF   (DOWN) FOODCOST                                   (ACROSS) CALORIES
```

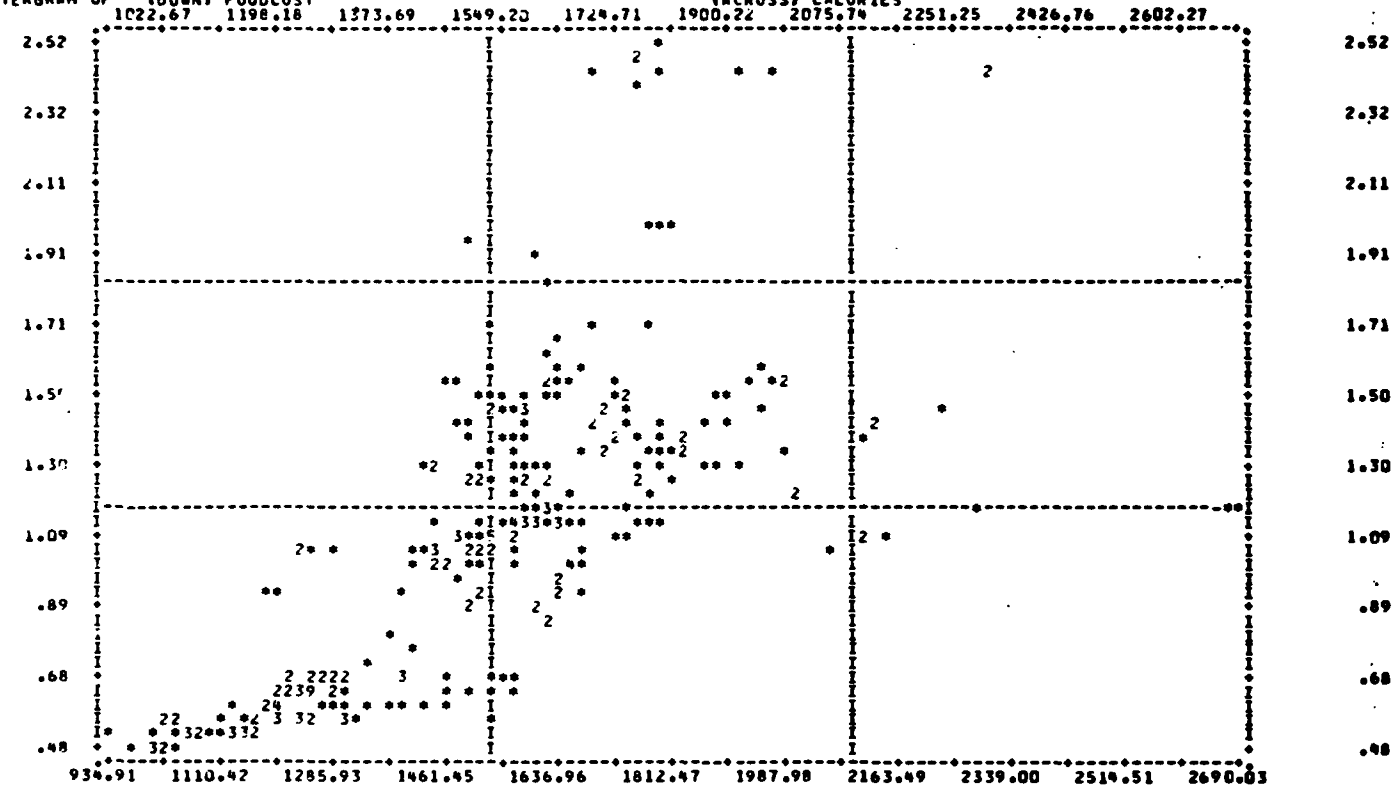


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CORRELATION OF MENU ATTRIBUTES BY PAIRS
FOOD COST VERSUS CALORIES (ALL MEALS)

STATISTICS..

  CORRELATION (R)-      .70725     R SQUARED      -      .50020     SIGNIFICANCE   -      .00000
  STD ERR OF EST -      .30790     INTERCEPT (A)  -     -.57740     SLOPE (B)      -      .00109
  PLOTTED VALUES -    325          EXCLUDED VALUES-     0           MISSING VALUES -     0

                 '*********' IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.
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Figure 6-6. Correlation of Food Cost vs Calories

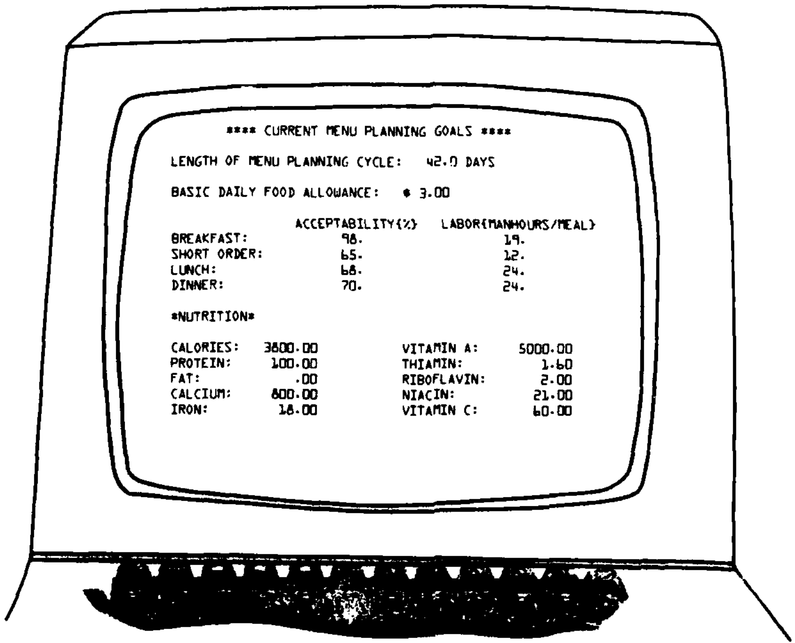

Figure 6-7. Menu Planning Goals

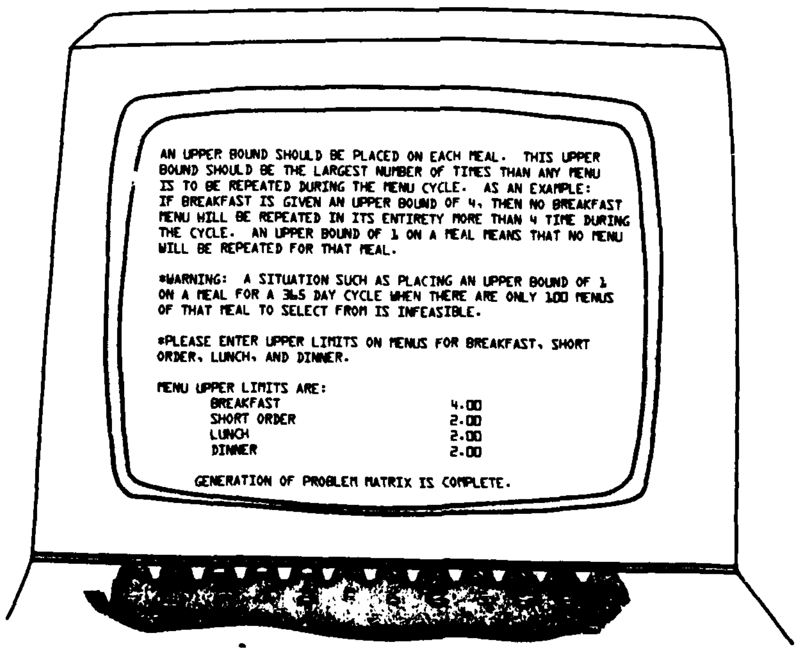

Figure 6-8. Menu Upper Bounds

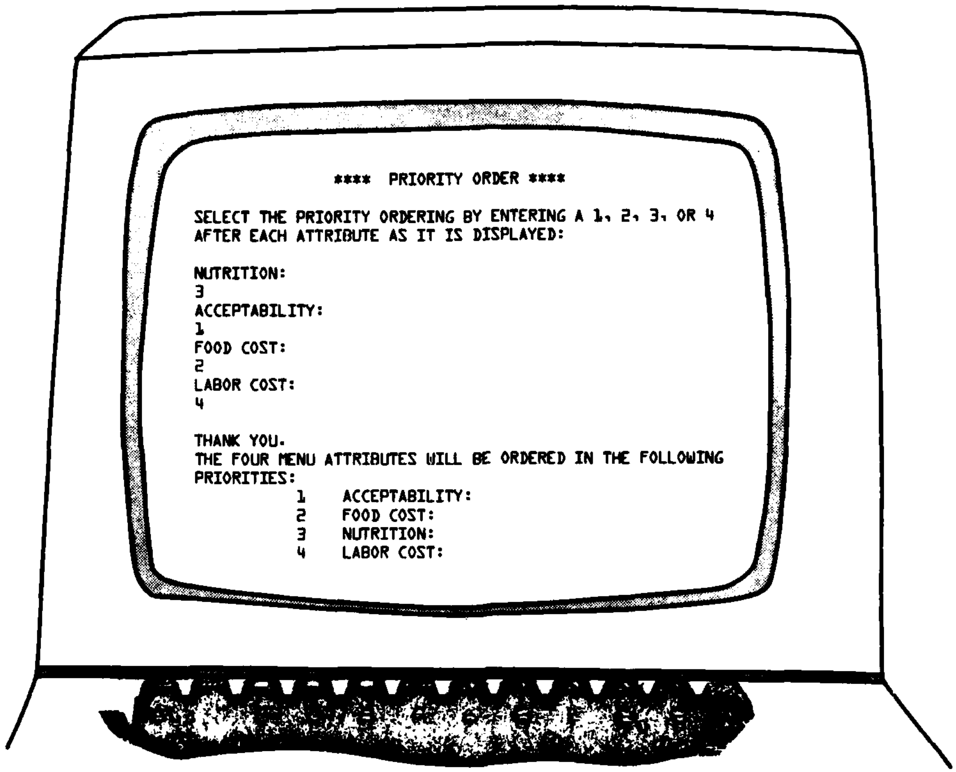

Figure 6-9. Menu Priority Ordering

(1) The menu plan that is produced at this point is probably not completely satisfactory due to any number of considerations. Without even looking at the menus that were selected, the menu planner may be able to judge the validity of the menu plan by looking at the report on goal achievement. This report is shown in Figure 6-10, and it is clear that the acceptability goals have been met, however the menu planner may not be satisfied with the deviation from the labor goals. As a result, the priority order may be changed to consider labor first, then food cost, followed by nutrition and acceptability. The results of this new plan are shown in Figure 6-11, where labor costs have been reduced by more than 9 manhours per day. The overall acceptability of the menu plan is not as high, but the menu planner may find it to be satisfactory.

ITEM	GOAL	DEVIATION	ACHIEVEMENT
ACCEPTABILITY (%)			
BREAKFAST	98.0	.0	98.0
SHORT-ORDER	65.0	-.0	65.0
LUNCH	68.0	.0	68.0
DINNER	70.0	.0	70.0
FOOD COST ($/INDIVIDUAL)			
BREAKFAST	.60	.00	.60
SHORT-ORDER	.72	-.34	.38
LUNCH	.48	.00	.48
DINNER	1.20	.00	1.20
LABOR (MAN-HOUR/MEAL)			
BREAKFAST	19.0	2.7	21.7
SHORT-ORDER	12.0	-.5	11.5
LUNCH	24.0	4.1	28.1
DINNER	24.0	3.1	27.1
FAT-CAL RATIO (INDIV/DAY)			
BREAKFAST	.00	.00	.00
SHORT-ORDER	.00	31.06	31.06
LUNCH	.00	-2.18	-2.18
DINNER	.00	-16.85	-16.85
NUTRIENTS (INDIV/DAY)			
CALORIES	3800.00	123.17	3923.17
PROTEIN (GM)	100.00	59.62	159.62
FAT	.00	174.46	174.46
CALCIUM (MG)	800.00	1093.02	1893.02
IRON (MG)	18.00	12.73	30.73
VITAMIN A (IU)	5000.00	3499.52	8499.52
THIAMIN (MG)	1.60	2.46	4.06
RIBOFLAVIN (MG)	2.00	4.14	6.14
NIACIN (MG)	21.00	17.62	38.62
VITAMIN C (MG)	60.00	88.75	148.75

Figure 6-10. Sample Goal Achievement, Acceptability, Food Cost, Nutrition, Labor

ITEM	GOAL	DEVIATION	ACHIEVEMENT
ACCEPTABILITY (%)			
BREAKFAST	98.0	-.9	97.1
SHORT-ORDER	65.0	-2.3	62.7
LUNCH	68.0	-7.0	61.0
DINNER	70.0	-3.3	66.7
FOOD COST ($/INDIVIDUAL)			
BREAKFAST	.60	-.05	.55
SHORT-ORDER	.72	-.32	.40
LUNCH	.48	.00	.48
DINNER	1.20	.00	1.20
LABOR (MAN-HOUR/MEAL)			
BREAKFAST	19.0	.1	19.1
SHORT-ORDER	12.0	-.1	11.9
LUNCH	24.0	.0	24.0
DINNER	24.0	.0	24.0
FAT-CAL RATIO (INDIV/DAY)			
BREAKFAST	.00	-1.54	-1.54
SHORT-ORDER	.00	33.79	33.79
LUNCH	.00	-5.83	-5.83
DINNER	.00	-2.69	-2.69
NUTRIENTS (INDIV/DAY)			
CALORIES	3800.00	188.15	3988.15
PROTEIN (GM)	100.00	58.67	158.67
FAT	.00	178.77	178.77
CALCIUM (MG)	800.00	1122.69	1922.69
IRON (MG)	18.00	14.92	32.92
VITAMIN A (IU)	5000.00	3374.73	8374.73
THIAMIN (MG)	1.60	2.44	4.04
RIBOFLAVIN (MG)	2.00	4.12	6.12
NIACIN (MG)	21.00	17.88	38.88
VITAMIN C (MG)	60.00	101.06	161.06

Figure 6-11. Sample Goal Achievement, Labor, Food Cost, Nutrition, Acceptability

(2) If the menu planner is satisfied with the relative goal achievement, the next step in validating the menu plan might be to check the repetition of recipes, especially the entrees. A portion of the recipe-menu cross reference listing is shown in Figure 6-12, where it may be noticed that recipe L-82, sweet and sour pork, is to be served six times in 42 days. This may be too often, and therefore the menu planner may decide to exclude a menu in which that recipe appears. As an example, menu number L-112 may be excluded as shown in Figure 6-13. There is no guarantee that another menu that includes recipe L-82 will not come into the solution; however, by continuing the process, the menu planner is able to refine the menu while assessing the goal achievement after each change.

```
**RECIPE L-69      (BAKED HAM                      ) IS SERVED IN THE FOLLOWING MENUS:
                   L-102
                   TOTAL TIMES SERVED =    2

**RECIPE L-72      (ROAST FRESH HAM                ) IS SERVED IN THE FOLLOWING MENUS:
                   L-051
                   TOTAL TIMES SERVED =    1

**RECIPE L-77-1    (SAVORY ROAST LAMB              ) IS SERVED IN THE FOLLOWING MENUS:
                   L-102
                   TOTAL TIMES SERVED =    2

**RECIPE L-82      (SWEET SOUR PORK                ) IS SERVED IN THE FOLLOWING MENUS:
                   D-031     D-088     L-112
                   TOTAL TIMES SERVED =    6

**RECIPE L-85-1    (GRILLED PORK SLICES            ) IS SERVED IN THE FOLLOWING MENUS:
                   L-066     L-095
                   TOTAL TIMES SERVED =    4

**RECIPE L-86      (BREADED PORK SLICES            ) IS SERVED IN THE FOLLOWING MENUS:
                   D-019     D-083
                   TOTAL TIMES SERVED =    3

**RECIPE L-88-2    (BAKED ITALIAN SAUSAGE          ) IS SERVED IN THE FOLLOWING MENUS:
                   L-010     L-083
                   TOTAL TIMES SERVED =    3

**RECIPE L-9       (BEEF POT ROAST                 ) IS SERVED IN THE FOLLOWING MENUS:
                   D-039     D-080
                   TOTAL TIMES SERVED =    4

**RECIPE L-9-1     (GINGER POT ROAST               ) IS SERVED IN THE FOLLOWING MENUS:
                   L-051
                   TOTAL TIMES SERVED =    1

**RECIPE L-9-2     (YANKEE POT ROAST               ) IS SERVED IN THE FOLLOWING MENUS:
                   D-007     D-020     D-092
                   TOTAL TIMES SERVED =    6

**RECIPE M-12      (COTTAGE CHEESE SALAD           ) IS SERVED IN THE FOLLOWING MENUS:
                   D-051     D-075
                   TOTAL TIMES SERVED =    4

**RECIPE M-18      (GARDEN COTTAGE CHEESE SLD      ) IS SERVED IN THE FOLLOWING MENUS:
                   D-032     L-001     L-049
                   TOTAL TIMES SERVED =    6

**RECIPE M-19      (GARDEN VEGETABLE SALAD         ) IS SERVED IN THE FOLLOWING MENUS:
                   L-023     L-056
                   TOTAL TIMES SERVED =    4

**RECIPE M-28      (JELLIED SPICED CHERRY SLD      ) IS SERVED IN THE FOLLOWING MENUS:
                   D-012     D-021
                   TOTAL TIMES SERVED =    3

**RECIPE M-32      (LETTUCE SALAD                  ) IS SERVED IN THE FOLLOWING MENUS:
                   D-013     D-019     D-022     D-065     L-040     L-067     L-087
                   TOTAL TIMES SERVED =   14

**RECIPE M-32-1    (LETTUCE WEDGE SALAD            ) IS SERVED IN THE FOLLOWING MENUS:
                   D-012     D-087     L-035     L-053     L-078     L-092
                   TOTAL TIMES SERVED =   12
```

Figure 6-12. Recipe Menu Cross Reference Listing

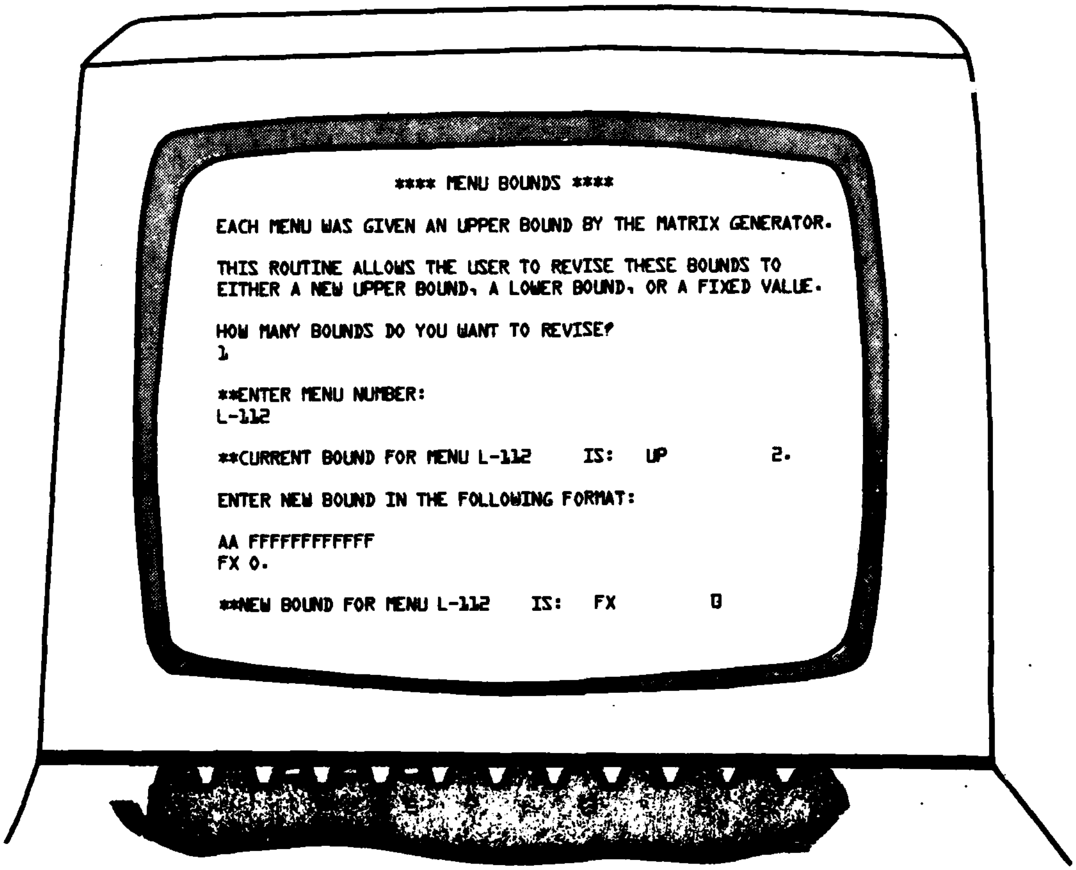

Figure 6-13. Revision of Menu Bounds

6-4. MOBILIZATION MENU PLANNING. In a 7 May 1980 letter, subject: Assessment of Mobilization Installation Capability to Provide Troop Support Service Under Full Mobilization, from the Director of Transportation, Energy, and Troop Support, ODCSLOG, guidelines for planning mobilization preparedness actions were outlined. The scenario envisioned a rapid escalation of requirements for installation troop support, with that support being provided from assets and resources that are already available or almost immediately obtainable from previously identified sources. The subsistence requisitioning, issue, and accounting system used under mobilization will be the Field Ration Issue System (FRIS) rather than the Army Ration Credit System (ARCS). The FRIS involves the requisitioning and issuing of subsistence on a meal basis following the SB 10-260, Master Menu and SB 10-263, 14-day US Army Reserve Component Menu. Under this system the TISO computes the requirements for each line item based on the number of meals requisitioned and effects a 100 percent issue of all ingredients.

a. The current DA Master Menu (SB 10-260) will serve as the basis for mobilization menu development since it will be readily available. It is expected that the locally developed mobilization menu will normally be more austere than that which is currently served during peacetime, e.g., multiple entrees and wide choices of vegetables and desserts will not be offered. Increased use of canned subsistence would be considered since such use would reduce cold storage requirements. Appendix F is an extract of the above letter and lists mobilization menu standards and a sample menu adaptation. The obvious emphasis is on providing wholesome nutritious food in adequate portions, but there will be an increased awareness of manpower requirements and less concern with the high acceptability factors that go along with multiple entrees.

b. The ability of the model to react to the different menu planning standards is dependent on the knowledge that the menu planner has of the system design. The data set would be one specially designed for mobilization planning. The menu component file would consist of menus that conform to the new standards. The recipe attribute file would probably not change, except that additional recipes of a less labor intensive nature might be added. The prioritization of goals would probably have labor as a high priority goal, while acceptability might be the last priority. Since there are only three meals to be planned, the input to the solution algorithm must be adjusted accordingly. When the solution matrix is generated, an upper bound of zero should be placed on short order meals implying that none are to be selected. The problem of establishing appropriate goals is more difficult. The user interface with the goals file allows for specific goals for the acceptability and labor cost of the short order meal. These may be set to zero. The goal for food cost, however, is simply entered as the value of the BDFA, and the short order goal is computed to be equal to the BDFA times .24. A structural goal for the number of menus of each type is also computed to be equal to the number of days in the cycle. As mentioned in an earlier chapter, the user is normally not aware of the actual file that the solution algorithm uses for the RHS values. The logical unit number of this file is 18, and the menu planners may use a text editor to alter the values of the goals. A file in which the goals for labor and acceptability have been set to zero by the user interface is shown in Figure 6-14. The structural goal and the food cost goals have been readjusted and changed via the text editor to those shown in Figure 6-15. The solution may then be generated as usual.

c. Because the model is designed to include both a short order and a lunch meal with a 60/40 acceptance ratio, the output will reflect the proper selection of menus but will not indicate the proper food cost or nutrients for the lunch meal. This is because the matrix generator reduced the food cost and nutritional coefficient by 40 percent.

d. It can be seen from the above discussion that while the methodology may be applied to mobilization menu planning, the menu planner must have a keen understanding of the model design to avoid misinterpretation of results.

```
* STRUCTURAL GOALS
    RHS       STB            42.0
    RHS       STS            42.0
    RHS       STL            42.0
    RHS       STD            42.0
* ACCEPTABILITY GOALS
    RHS       ACB           4116.
    RHS       ACS              0.
    RHS       ACL           2856.
    RHS       ACD           2940.
* FOOD COST GOALS
    RHS       FCB        2520.00
    RHS       FCS        3024.00
    RHS       FCL        2016.00
    RHS       FCD        5040.00
* LABOR COST GOALS
    RHS       LCB            798.
    RHS       LCS              0.
    RHS       LCL           1008.
    RHS       LCD           1008.
* NUTRITIONAL GOALS
    RHS       N01       15960000.          CALORIES
    RHS       N02         420000.          PROTEIN
    RHS       N03              0.          FAT
    RHS       N04        3360000.          CALCIUM
    RHS       N05          75600.          IRON
    RHS       N06       21000000.          VITAMIN A
    RHS       N07           6720.          THIAMIN
    RHS       N08           8400.          RIBOFLAVIN
    RHS       N09          88200.          NIACIN
    RHS       N10         252000.          VITAMIN C
```

Figure 6-14. Partially Modified Mobilization Goals

```
* STRUCTURAL GOALS
    RHS       STB            42.0
    RHS       STS             0.0
    RHS       STL            42.0
    RHS       STD            42.0
* ACCEPTABILITY GOALS
    RHS       ACB           4116.
    RHS       ACS              0.
    RHS       ACL           2856.
    RHS       ACD           2940.
* FOOD COST GOALS
    RHS       FCB        2520.00
    RHS       FCS           0.00
    RHS       FCL        5040.00
    RHS       FCD        5040.00
* LABOR COST GOALS
    RHS       LCB            798.
    RHS       LCS              0.
    RHS       LCL           1008.
    RHS       LCD           1008.
* NUTRITIONAL GOALS
    RHS       N01       15960000.          CALORIES
    RHS       N02         420000.          PROTEIN
    RHS       N03              0.          FAT
    RHS       N04        3360000.          CALCIUM
    RHS       N05          75600.          IRON
    RHS       N06       21000000.          VITAMIN A
    RHS       N07           6720.          THIAMIN
    RHS       N08           8400.          RIBOFLAVIN
    RHS       N09          88200.          NIACIN
    RHS       N10         252000.          VITAMIN C
```

Figure 6-15. Modified Mobilization Goals

6-5. SUMMARY. Within the limitations of the data set, the Master Menu Model is an effective tool that the menu planner may use to produce valid menu plans and to evaluate alternatives in menu design. The menu planner should have a clear understanding of the data set and should understand the concepts involved in the model's design. Flexibility and speed are key features that enable the menu planner to evaluate quickly the results of changes in menu planning parameters.

a. Limitations

(1) The model has several limitations, some of which were imposed by the study limitations and others which are inherent in the methodology. The fact that menus are not scheduled is a limitation that may seem more significant than it really is. The fact is that without information concerning the planning calendar and the pairwise compatibility of menus, the job of scheduling could not be done well, and was therefore better left to the menu planners. Another limitation is the inability to control directly the repetition of recipes. The process of bounding out menus only partly addresses the problem, but experience indicates that this process of bounding out and fixing in different menus is a good approximation of the manual process with the benefit of being able to analyze the effect of such changes. An additional problem that is rarely apparent is in the solution algorithm itself. The GP algorithm is not an integer programing algorithm, and therefore noninteger solutions are possible. The postprocessor does some rounding of the solution whenever necessary; however, there are cases when the rounding process results in listing more or less menus than are necessary for the cycle length, such as listing 43 or 41 breakfast menus for a 42-day cycle. Changing priorities, altering goals, or reestablishing bounds will usually eliminate this anomaly.

(2) An additional limitation of the model is in the realm of mobilization menu planning. Although the model may be used to plan mobilization menus, the relationship between the lunch and short order meals has been built into the model. A procedure for planning mobilization menus has been discussed, but interpretation of output is difficult because the results of food cost and nutrition for the lunch meal have been reduced by 40 percent. In the case of food cost, the amount shown in solution output for lunch is 40 percent of the true value and therefore should be divided by .4 to yield the actual cost of lunch. Nutritients, on the other hand, are not broken out by meal, and as a result, the actual values may not be directly determined.

b. Observations. The effects of a limited data set on possible solutions may be significant. In addition, unrealistic goals may so constrain the model that it cannot be used to its full advantage. A logical process of selectively refining the menu plan by altering the priority order and planning parameters will result in menu plans that make sense, both to the analyst and to the average diner.

CHAPTER 7

CONCEPT OF OPERATION

7-1. INTRODUCTION. As outlined in the previous chapter, the Master Menu Study resulted in the development of both a methodology and a working model. It is intended that the methodology and the model be applied to the menu planning process at TSA. During the course of the study, the study team had the opportunity to travel to Fort Lee to meet with key personnel in the areas of administration, menu planning, and concept and system development. Meetings were also held between the study team members, representatives from ALMC, and GSA contractors who were working on the development of a food service management information system. As a result of these meetings and through a knowledge of the Master Menu Model capabilities, a concept of operations involving the model's use evolved. The purpose of this chapter is to outline that concept of operations and to make recommendations concerning the validation and implementation of the model.

7-2. VALIDATION. Validation of the model may be done in the following three phases:

a. Testing at CAA. The model has been tested and validated at CAA as part of the current study. The results of that process have been detailed in this report. The validation could only be conducted within the context of a limited data set; however, in tests designed to compare menu plans produced by the model with actual plans designed by TSA, the model results were very favorable. In one test, the model produced a plan that reduced daily caloric intake by 387 calories per individual below a TSA-produced plan while maintaining the adequacy of nine other nutrients. The ability to realize significant savings in labor costs and to develop highly acceptable menu plans was also demonstrated.

b. Testing at TSA. The validation process at TSA may be one that is continued over a period of time. The validation plan may include the elements listed in Table 7-1.

c. Field Testing. The ultimate validation of the model is determined by how well the menu plans are utilized in the field. Since deviations from the Master Menu are allowed, the measure of performance may be in the form of feedback from the dining facility managers. Another element to field testing will occur at TSA. Because the model is intended to be a design tool for the menu planners, there is no doubt that their assessment of the model will be part of the validation process. For this reason it is important that the menu planners become involved as early as possible.

Table 7-1. Elements of the Validation Plan

- Appointment of a project manager responsible for model validation.
- Establishment of a valid data set.
- Definition of standards against which the model's performance is to be measured.
- Establishment of a timetable for completion of the validation process.
- Involvement of menu planning personnel.

7-3. IMPLEMENTATION. Implementation of the model may be done in the following two phases:

a. Implementation as a Decision Tool. The model can be implemented as a decisionmaking tool for the menu planners immediately after it is placed into operation. Even with a limited data set, the relative worth of "test" menus may be evaluated. Through this process, the menu planners may be able to gain new insight into resource tradeoffs.

b. Implementation as a Production Model. The implementation as a production model may have to wait until TSA has validated the model and a satisfactory data set has been developed. The role of the Master Menu Model in the production process was never intended to be all-inclusive. There is an essential role to be played by the dietitians, and therefore the reference to use as a production model does not imply that the output of the model is to be published without change in SB 10-260.

c. Management Prescriptions. The prescriptions below are recommendations concerning training, implementation, and integration of the model into the existing menu planning process. The recommendations are based on a recognition that use of the Master Menu Model may entail a significant departure in attitudes and concepts from those associated with the current process.

(1) Designation of a Transition Group. Important to this process is the designation of a transition group to monitor and supervise the process of implementing the model. The group should include an experienced systems analyst who will ultimately become the system "expert." This person should develop a familiarity with the complex aspects of the model so that questions concerning model capabilities and performance

may be answered on site. In addition, the group should include a senior member of the menu planning section who can identify functional and training requirements. As one of its functions, the group should identify those enhancements that may assist in developing the model into a fully integrated part of the planning process.

(2) Designation of Milestones. A set of milestones for the implementation of the model should be established. These milestones should incorporate all aspects of the system including the training of personnel and validation of data.

(3) Training. The TSA transition group should establish training requirements and monitor the adequacy of that training. The full potential of the model can only be realized if the menu planners themselves feel comfortable with their ability to interact with the model through a conveniently located computer terminal.

(4) Integration With a Database. The process of maintaining valid data would be eased greatly by the acquisition of a database management system which incorporates the capability to alter recipe attributes based on changes in food item attributes. It should also allow indexing of recipes according to meal components and be able to produce data files that may be loaded by the model into the recipe attribute file and the menu component file. Integration with a database management system will allow the menu planners to identify the effect of solutions on attributes such as equipment, that were excluded from this study.

d. System Concepts. The following system concepts will assist in integration and implementation of the model.

(1) Terminals. Remote computer terminals should be available to the menu planners in a location that is convenient to them.

(2) Line Printers. Printed output should be readily retrievable.

(3) Maintenance of Alternative Data Sets. Since many applications will be concerned with exploring specific concepts such as producing less labor intensive menus, alternative data sets should be developed and maintained. As explained in previous chapters, the model is data dependent, and for certain applications, the model may be most responsive to data that exhibit special characteristics. Because the model incorporates the ability to load alternative data files, data may be saved, reloaded, changed, and saved again.

(4) Designation of a data manager responsible for maintenance of backup files is important to assure the validity of data and prevent unauthorized changes to data files. In general, the model should be accessed by no more than one person at a time.

7-4. EVOLUTION OF THE MODEL. As with any model, there will be an evolutionary process associated with this model. That evolution should be controlled by clearly identifying the needs and putting those needs in terms of specific functions. Several enhancements may eventually be considered, including the following:

a. Expansion of Data Set. The limits of the data set may be expanded, although the present limits pervade the entire model.

b. Equipment. Inclusion of equipment requirements as a fifth attribute is not recommended. Solutions may be evaluated in terms of equipment requirements, but it is not recommended that more than the currently considered attributes be included in the optimization process.

c. Scheduling. A scheduling algorithm would be a desirable enhancement to the model but might require additional data concerning pairwise compatibility of menus.

d. Incorporation of New Nutritional Requirements New nutritional requirements are anticipated to be in three forms:

(1) Changes to Requirements for Currently Considered Nutrients. These changes may be reflected in the framework of the existing model by changing goal values. The draft revision to AR 40-25 reduces the contribution of calories from fat sources from 40 percent to 35 percent. For this change to be reflected in the model, a very minor change to the matrix generator would have to be made.

(2) Consideration of New Nutrients. Dropping one nutrient and replacing it with another may simply involve changing the name of the nutrient in all the input/output processes. Adding new nutrients to those currently considered would involve major changes to the model. Experience with the model has shown that only two nutritional factors are actually driving the solutions--fats and calories. This is because in practice all the other nutritional goals are easily achieved. This implies that the addition of more nutrients, especially nutrients for which the recommended allowance is very small (such as iodine), would contribute little to the model.

(3) Consideration of Nutrient Density Indexes. A major enhancement to the model in terms of the way in which it deals with nutrition would be through use of nutrient density indexes. This would involve a substantial revision of the model; however, the framework for the procedure would be the same as that used in the current model to deal with the fat/calorie ratio requirements.

e. Expansion of the Math Model. As new requirements are recognized and as the concepts employed in this model are explored, it may be desirable to expand the math model by the inclusion of more constraints or objectives. These changes would probably require significant changes to the entire model, but in many cases, a simple revison of the matrix generator might suffice.

f. Mobilization Planning. A possible enhancement to the model would include user control over standard or mobilization menu planning. This would simplify the process of planning mobilization menus and assessing model output.

7-5. MANGEMENT INFORMATION SYSTEM (MIS) INTERFACE. Although the model has a substantial data handling capability, the addition of an MIS would reduce the time required to establish valid data sets and would enable the menu planner to analyze the parameters of the data set more completely.

CHAPTER 8

SUMMARY AND OBSERVATIONS

8-1. INTRODUCTION. The Master Menu Study resulted in the development of a methodology and associated model which can be used to analytically guide the preparation of the Army Master Menu. The essential elements of analysis (EEA) provided in the study directive focused on the usefulness of the study product, both in terms of the validity of the methodological approach and the delivery of a working menu planning model. The model methodology was discussed (see Chapters 3 and 5), along with the factors that contributed to the development of that methodology. The model itself was discussed in Chapters 4 and 6, while management prescriptions for model validation and implementations were presented in Chapter 7. This chapter summarizes the effort of the Master Menu Study by specifically addressing the EEA required by the tasking directive, and concludes with several observations concerning the study.

8-2. ESSENTIAL ELEMENTS OF ANALYSIS. The EEA which guided the conduct of the study are stated and discussed below.

a. <u>Does the methodology provide a product which is useful in the design of the Master Menu?</u> Yes. This EEA specifies that the methodology is to be analyzed in terms of how useful it can be to the menu planners. The model was designed with consideration of the current menu planning process. The emphasis in model design was on flexibility, ease of operation, accuracy and reliability. The concept of integrating the model into the existing system was considered so that the menu planners would find the model useful for maintenance of data, assessment of the relative worth of menus, and development of complete menu plans. A concern with making the model as user friendly as possible has resulted in a model that the menu planners should feel comfortable operating on a daily basis. It must be emphasized that in assessing the usefulness of the product, attention should be given to the fact that menu planners will have the capability to rapidly and efficiently perform tasks that they had previously performed either manually or not at all. Some of those tasks are listed in Table 8-1.

Table 8-1. Model Tasks

- Maintenance of a data base of recipes and associated attributes.
- Consistent analytical evaluations of menus in terms of attributes of food cost, labor, acceptability, and nutrition.
- Rapid and efficient modification of menu planning goals and priorities.
- Production and assessment of complete menu plans.

b. Does the model provide a useful tool for obtaining insights into food service resource allocation in consideration of changes in priorities, resource cost, preference patterns, and nutritional requirements? Yes. The ability to reorder priorities and rapidly rerun the model has made the identification of resource tradeoffs a fairly simple process. The effect of reassessing the menu planning goals was demonstrated in Chapter 6. It was shown that what may appear to be logical assumptions regarding the correlation of menu attributes may not be accurate, and that as a result, the model proved to be a useful tool in assessing the real worth of menus in terms of the prioritized set of goals. The data handling module was designed to allow for the simple modification of food cost, labor cost, acceptability, and nutritional data for any recipe. Changes to these recipe attributes were reflected in the menu attributes through a consistent analytical process. The ability to assess changing priorities, goals, and menu attributes is an overwhelming task for any menu planner yet one which the model was able to perform in a few minutes. The nature of the reports produced by the model allowed the menu planner to rapidly assess the validity of the various menu plans.

c. Is the methodology appropriate for future applications to mobilization conditions? Yes. As explained in Chapter 6, mobilization imposes special considerations on the menu planning process. The appropriateness of the methodology is not changed by those considerations, and specific procedures were demonstrated whereby the model would be used to plan mobilization menus.

d. Can the program be made transportable for use on computer systems which are available to TSA? Yes. Portability was a prime consideration in model design. The mathematical programing package, XMP, was selected primarily on the basis of portability. XMP consists of three versions, and because of the difference in word length, the versions employed at CAA and at TSA are slightly different. All computer programs were written to conform with FORTRAN 77 standards. Some of the intrinsic functions had to be modified along with hashing algorithms and sort routines which were system dependent.

8-3. OBSERVATIONS. The major observations resulting from this study are presented in the following material:

a. The menu planning process at TSA can be significantly improved by a more comprehensive use of computers. The menu planning model is only a part of the process. A well defined, yet flexible management information system should be designed to interface with the model in order to realize the full potential of the model. To say that the process can be improved is not intended as an indictment of the existing system. The menu planners do an extraordinary job of balancing a number of subjective factors in the development of highly acceptable menu plans. Portions of the process cannot be done by any computer algorithm, and it is in recognition of this that the model was designed to let the menu planner "work smarter and not harder."

b. The inclusion of labor costs in the menu planning process is highly appropriate; however, the validity of the labor data should be closely scrutinized.

c. Recipe and menu acceptability are the attributes that are subject to the greatest misinterpretation. If the assumptions regarding recipe acceptability are to hold true, there should be a process for determining acceptability that is in keeping with a valid experimental design. Menu acceptability should never be interpreted to be more than what it is: a single factor by which menus of the same meal type may be compared in the GP solution algorithm.

d. The model has a tendency to bring menus in at their upper bound. These upper bounds should be set in careful consideration of the data set and with regard to the amount of repetition that is inherent in the meal structures. As an example, breakfast menus tend to be very repetitive in nature and often the only difference between menus is the beverage. In addition, the menu planners may find that the cross reference listing will indicate where bounds need to be changed. The main reason why the model tends to bring menus in at their upper bounds is that the mathematical model is not as constrained as it might be. The model would be enhanced by the inclusion of additional constraints. Appropriate constraints will probably present themselves as the model is used in a practical environment.

e. The use of a goal programing algorithm in the menu planning model reflects the nature of the problem--prioritizing the achievement of several menu planning goals. It must be recognized, however, that GP is a fairly complex subject, and one that even most operations research analysts are not familiar with. The user interfaces hide some of the complexity, but any attempts to modify the GP algorithm should be carefully considered. The programs are documented in sufficient detail to allow a knowledgeable programer to make changes, but, in general, it may be said that no changes should be made to any of the XMP subroutines with the exception of adjusting parameters in the main program.

f. The final observations concern the philosophy of model implementation. The model is a highly flexible menu planning tool. It is very user friendly, but the user must understand the model structure. Menu planning is a complex process, and the model should be used to control this complexity. The model is intended to address the problems of today's Army--high costs, scarce personnel resources, increased consciousness regarding nutrition, and changing preference patterns--but the model is also intended to make the menu planner's job easier not harder.

APPENDIX A

STUDY CONTRIBUTORS

1. STUDY TEAM

   a. Study Director

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   b. Team Members

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      Dr. Dong Kim, Mathematician
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3. PRB MEMBERS

   Stanley H. Miller, Chairman
   MAJ Tony Tyson, Member
   CPT Jim Dernar, Member

APPENDIX B

STUDY DIRECTIVE

DEPARTMENT OF THE ARMY
DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, D.C. 20310

DALO-TST 402759-5 28 DEC 1981

SUBJECT: Econometric Model for Optimizing Troop Dining Facility Operations

Commander
US Army Concepts Analysis Agency
8120 Woodmont Avenue
Bethesda, Maryland 20014

1. **PURPOSE OF STUDY DIRECTIVE.** This directive provides for the development of a methodology and associated models to produce a design tool which can be used to analytically guide the preparation of the Army Master Menu.

2. **BACKGROUND.**

a. In accordance with AR 30-1, the Master Menu is published by the Troop Support Agency (TSA), Ft. Lee, Virginia as a guide for use in Active Army dining facilities. Factors which must be considered in the development of the Master Menu are raw food cost, prescribed nutritional requirements, and acceptability. Although labor cost is not currently considered in the development of the Master Menu, it is a factor for future consideration. Rising costs and increased consciousness regarding the acceptability and nutritional adequacy of diets necessitate efficient menu planning.

b. The current method of developing the Army Master Menu is a subjective analysis using manual and partially automated procedures. There is presently no efficient means by which the Army may determine the effect of changes in resource costs, nutritional requirements, and preference patterns on the design of the Master Menu. Scientific approaches to menu planning have generally taken the approach of attempting to optimize a single factor such as achieving the least cost menu. The advent of goal programing has resulted in an efficient tool which may be used to address menu planning as a real world problem of achieving multiple, and often conflicting, objectives.

3. **STUDY SPONSOR.** Office of the Deputy Chief of Staff, Logistics (ODCSLOG).

4. **STUDY AGENCY.** US Army Concepts Analysis Agency (CAA).

DALO-TST 28 DEC 1981
SUBJECT: Econometric Model for Optimizing Troop Dining Facility Operations

5. TERMS OF REFERENCE.

a. Scope. This study is intended to provide a design tool which can be utilized to guide the preparation of the Army Master Menu in garrison conditions and to provide a demonstration of application.

b. Objective.

(1) Identify the following parameters of the Master Menu:

(a) Recipes. Recipes are defined as being a ready to eat menu item which is the end result of a process of food preparation. A representative sampling of recipes is to be identified for inclusion in the study.

(b) Menu. A menu is a listing of the particular items to be served in a dining facility for a given meal. A representative sampling of menus is to be identified for inclusion in the study.

(c) Raw Food Cost. The cost of individual recipes in terms of the cost of the raw foods comprising the recipes is to be identified. Appropriate goals for raw food costs are also to be identified.

(d) Labor Cost. The cost of individual recipes in terms of the numbers of manhours involved in preparing the recipes is to be identified. Appropriate goals for labor costs are also to be identified.

(e) Nutrients. The nutritional content of individual recipes is to be identified and quantified. Appropriate nutritional goals are to be identified.

(2) Design the methodology for applying goal programing to menu planning to include:

(a) Developing computer programs which will generate the goal programing problem matrix from tables of recipes and selected menus and their associated attributes.

(b) Developing a goal programing model which will prioritize the achievement of goals for raw food cost, labor cost, acceptability, and nutritional adequacy in the design of the Army Master Menu.

(3) Apply the methodology to the design of a sample 42-day Master Menu based on serving 100 individuals in accordance with the policies and procedures of the Army Ration Credit System (ARCS).

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c. Limitations. It is not anticipated that the study will:

(1) Address the problem of designing menus for individual meals.

(2) Address the problem of pairwise compatibility of meals for a particular day.

(3) Address the requirements of short order and specialty dining facilities.

(4) Perform an analysis for optimization of staffing, storage requirements, or equipment utilization.

d. Constraints. This study is to be completed by 31 October 1982.

e. Assumptions.

(1) Data concerning recipe attributes for raw food cost, labor cost, nutritional content, and acceptability as provided by TSA are acceptable as input to this study.

(2) Problem formulation as a linear, deterministic mathematical model provides an adequate representation of the system under study.

f. Essential Elements of Analysis (EEA).

(1) Does the methodology provide a product which is useful in the design of the Master Menu?

(2) Does the model provide a useful tool for obtaining insights into food service resource allocation in consideration of changes in priorities, resource costs, preference patterns, and nutritional requirements?

(3) Is the methodology appropriate for future applications to mobilization conditions?

(4) Can the programs be made transportable for use on computer systems which are available to TSA?

g. Environmental Impact. No environmental consequences are envisioned; however, the study agency is required to surface and address any environmental considerations that develop in the course of the study effort.

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h. Estimated Cost Savings. Savings will be identified as the study methodology is incorporated into the development of the Master Menu.

6. RESPONSIBILITIES.

a. The ODCSLOG will:

(1) Provide a sponsor's study technical representative.

(2) Designate a study director. A Study Advisory Group (SAG) is not required.

(3) Designate a point of contact (POC) at TSA.

b. TSA will:

(1) Provide guidance on food service policies and procedures.

(2) Provide data for the following recipe attributes:

(a) Raw food cost

(b) Labor cost

(c) Nutritional value

(d) Acceptability

(3) Provide computer systems analyst support to assist in making the model transportable for use on the computer systems which are available to TSA.

c. CAA will:

(1) Designate a principal investigator and establish a full-time study team.

(2) Establish direct communication with ODCSLOG, TSA, and other agencies as required for the conduct of the study.

(3) Provide periodic In Progress Reviews (IPR) and final study documentation to the study sponsor through the study director.

(4) Provide programing and ADP support as required for the conduct of the study.

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7. LITERATURE SEARCH.

a. The following organizations will have interest in the subject matter of the study.

(1) ODCSLOG

(2) TSA

(3) Office of The Surgeon General (OTSG)

(4) US Army Natick Laboratories

b. No previous studies are known to have addressed the application of goal programing to menu planning.

8. REFERENCES.

a. AR 5-5. with Change 1, The Army Study Program

b. DA PAM 5-5, Guidance for Study Sponsors and Study Advisory Groups

c. AR 30-1, The Army Food Service Program

d. Concept of Design and Operations for Army Dining Facilities, TSA, July 1980

9. ADMINISTRATION.

a. Support.

(1) Funding for temporary duty (TDY) and travel associated with the study will be provided by each participating agency.

(2) Automatic data processing equipment (ADPE) will be provided by CAA.

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b. Milestone schedule.

First IPR	Jan 1982
Second IPR	Mar 1982
Third IPR	Jun 1982
Final IPR	Sep 1982
Final Report published	Oct 1982

c. Control procedures.

(1) The ODCSLOG will designate a study director. Periodic IPRs will be provided to the study director by the study team.

(2) The ODCSLOG study technical representative will serve as the day-to-day contact for the study within the ARSTAF.

(3) Documentation required by AR 5-5, including DD Forms 1498 to DLSIE and DTIC; DD Forms 1473; and final reports will be prepared and submitted by the study agency.

d. Action Document. Final study documentation consisting of a technical paper and system documentation will be provided to the study sponsor.

e. Coordination. This study directive has been coordinated with CAA in accordance with AR 10-38.

RICHARD H. THOMPSON
Lieutenant General, GS
Deputy Chief of Staff for Logistics

APPENDIX C

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Hillier, Frederick R. and Lieberman, Gerald J., Operations Research, 2d ed., Holden-Day, Inc., San Fransisco, CA, 1974

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Marsten, Roy E., The Design of the XMP Linear Programming Library, ACM Transactions on Mathematical Software, December 1981

Eckstein, Eleanor F., Menu Planning, AVI Publishing Co., Westport, CN, 1978

APPENDIX D

ARMED FORCES MENU STANDARDS*

Minimum Standard	Standard
1. GENERAL	1. GENERAL
A. Menus planned for weekends, weekdays and all holidays should adhere to the minimum standards.	A. Menus planned for weekends, weekdays and all holidays should adhere to the standards.
B. Menu combinations offered at each meal will provide variety and contrast in texture, flavor and color.	B. Same.
C. Skim milk, low fat milk, buttermilk and sherbet will be offered to the degree required by customer requests.	C. Same.
2. NOON AND EVENING MEALS (does not include Short Order meal)	2. NOON AND EVENING MEALS (does not include Short Order meal)
A. With the exception of when grilled steak is served, a choice of two different types of entrees should be offered every customer when possible.	A. A choice of three different types of entrees with at least two choices will be offered every customer.
B. Attention will be given to the spacing of menu entrees to avoid close repetition of similar items.	B. Same.
C. When one entree choice is a cold meat platter, cold sliced roast meat such as beef, ham, pork and/or turkey will be included.	C. Same.
D. An appropriate sauce, gravy or garnish should be planned to accompany the entrees.	D. One or more appropriate sauce, gravy or garnish will be planned to accompany the entrees.

Minimum Standard	Standard
E. Potatoes and/or a potato substitute will be offered at each meal to complement the entrees.	E. A choice of potatoes and/or potato substitutes will be offered at each meal to complement the entree.
F. Two cooked vegetables will be offered at each meal, except special sandwich, cold meat platter, or spaghetti-type meals need not have a choice.	F. Two or more cooked vegetables will be offered at each meal; one of which will be a dark green or deep yellow vegetable.
G. Not more than one gas-forming cooked vegetable such as cabbage, cauliflower, broccoli, onions, brussels sprouts, and dried beans will be offered at a meal.	G. Same.
H. A choice of at least two salads will be offered at each meal; one will be a few leafy vegetable type salad.	H. A salad bar with at least three but not more than eight salads will be offered at each meal.
I. The selection of salads for each meal will be varied to avoid repetitious serving of the same salad.	I. Same.
J. Salad dressing, vinegar and oil and a choice of Bleu Cheese, Thousand Island, French or Italian dressing will be served at each meal. Additional dressings may be offered when appropriate to salad selections.	J. Salad dressing, vinegar and oil, Bleu Cheese, French, Thousand Island and Italian dressings will be served at each meal. Additional salad dressings will be offered when appropriate to salad selections.
K. Not less than two choices of bread (white, whole wheat or rye) or one choice of hot rolls, muffins or biscuits will be offered at each meal.	K. A selection of not less than three breads and a selection of hot rolls, muffins and biscuits will be offered at each meal.
L. Butter, or margarine when authorized, and choice of two or more spreads (jam, jelly, peanut butter, etc.) will be offered at each meal.	L. Same.

Minimum Standard	Standard
M. At least one soup will be offered daily. The type offered will vary from noon to evening meal and from day to day.	M. Same.
N. A choice of two or more different types of desserts will be offered at each meal. Cookies may be served as an accompaniment to ice cream, pudding or gelatin when these items are offered as a dessert choice; cookies alone will not be offered as a dessert choice. Fruit will be offered to the degree required by customer requests.	N. Three or more different types of desserts will be offered at each meal. Cookies may be served as an accompaniment to ice cream pudding or gelatin when these items are offered as dessert choices; cookies alone will not be offered as a dessert choice. Fruit will be offered to the degree required by customer requests.
O. Milk, soft drinks, coffee and tea will be offered at each meal.	O. Milk, soft drinks, including carbonated beverages, coffee and tea will be offered at each meal.
3. BREAKFAST	3. BREAKFAST
A. A choice of juices or a choice of fruit and juice will be offered, at least one of which will be citrus.	A. A choice of orange juice, another juice and fruit (preferably fresh) will be offered.
B. A choice of at least four different ready-to-eat cereals will be offered; hot cereal or hominy grits will be offered at least once a week.	B. A choice of a hot cereal or hominy grits, and at least four different ready-to-eat cereals will be offered.
C. Eggs to order will be offered.	C. Eggs to order including omelets will be offered.
D. A choice of griddle cakes or French toast will be offered.	D. Griddle cakes and French toast will be offered.
E. At least one breakfast meat will be offered daily. Bacon will be offered at least five days a week.	E. Bacon and at least one other breakfast meat will be offered daily.

Minimum Standard	Standard
F. Potatoes or a potato substitute such as hominy grits should be offered at least three times a week.	F. Potatoes or a potato substitute such as hominy grits will be offered daily.
G. Toast will be offered daily; a breakfast pastry or doughnut should be offered at least four days a week.	G. Toast and at least one breakfast pastry or doughnut will be offered daily.
H. Butter, or margarine where authorized, syrup and choice of two or more spreads (jam, jelly, peanut butter, etc.).	H. Same.
I. Milk, coffee, and tea will be offered. Cocoa will be offered to the degree required by customer requests.	I. Same.
J. Continental style breakfast will be offered daily in addition to the regular breakfast.	J. Same.
4. SHORT ORDER	4. SHORT ORDER
A. Soup and/or chili con carne will be offered daily	A. Same.
B. Hamburgers, cheeseburgers, frankfurters, and at least one other short order type entree will be offered daily.	B. Hamburgers, cheeseburgers, frankfurters and at least two other short order type entrees will be offered daily.
C. French fried potatoes, potato chips or corn chips will be offered daily.	C. French fried potatoes and potato chips or corn chips will be offered daily.
D. A choice of at least two salads will be offered at each meal; one will be a raw leafy green vegetable type salad.	D. A salad bar with at least three but not more than eight salads will be offered at each meal.

Minimum Standard	Standard
E. The selection of salads for each meal will be varied to avoid repetitious serving of the same salads.	E. Same.
F. A choice of two or more different types of desserts will be offered at each meal. Cookies may be served as an accompaniment to ice cream, pudding or gelatin when these items are offered as dessert choices; cookies alone will not be offered as a dessert choice. Fruit will be offered to the degree required by customer requests.	F. Three or more different desserts will be offered at each meal. Cookies may be served as an accompaniment to ice cream, pudding or gelatin when these items are offered as dessert choices; cookies alone will not be offered as a dessert choice. Fruit will be offered to the degree required by customer requests.
G. Milk, soft drinks, coffee, and tea will be offered at each meal.	G. Milk, soft drinks, including carbonated beverages, coffee, and tea will be offered at each meal.
H. None.	H. Soft-serve ice cream and/or milk shakes will be available at each meal.

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*SOURCE: Concept of Design and Operations for Army Dining Facilities, US Army Troop Support Agency, FT Lee, VA, 25 July 1980.

APPENDIX E

INTRODUCTION TO XMP

The following XMP documentation is reprinted in its entirety by permission of the author, Professor Roy E. Marsten.

Introduction to XMP.

Date last modified: July 20, 1981

XMP is a structured library of subroutines for experimental mathematical programming. Development of the original version of the XMP library was supported by the National Science Foundation under grants MCS76-01311 and MCS76-01311 AD1 (1976-1978) to the Center for Computational Research in Economics and Management Science at the Massachusetts Institute of Technology. (At the time of the initial grant, the Center was part of the National Bureau for Economic Research, Inc.) The principal investigator was Roy Marsten.

XMP is now being distributed to universities and government agencies by the Department of Management Information Systems at the University of Arizona and to corporations by the XMP Optimization Software Co.

A thorough introduction to XMP is contained in: The Design of the XMP Library, Transactions on Mathematical Software, to appear December 1981.

Inquiries concerning XMP should be directed to:

Prof. Roy E. Marsten
Department of Management Information Systems
College of Business and Public Administration
University of Arizona
Tucson, Arizona 85721

Phone: (602) 626-3116

The current version of XMP uses the LA05 Routines from the Harwell Library to manage an LU Factorization of the basis matrix. The LA05 Routines were written by John K. Reid. Inquiries concerning the Harwell Library should be directed to:

Computer Science and Systems Division
AERE Harwell
Oxfordshire, England

Reference: FORTRAN Subroutines for Handling Sparse Linear Programming Bases, John K. Reid, Report AERE-R8269, January, 1976.

The standard XMP tape contains three files.

File 1.	System documentation and the data for a small test problem in the form that can be read by the sample user program.
File 2.	Three different versions of the XMAPS Routine and three different versions of the six Harwell Routines (LA05A, LA05B, LA05E, MC2DA, MC2DB). The three versions are suitable for DEC, IBM, and CDC computers. These three versions have sufficed for all of the computers that have been encountered so far.
File 3.	The sample user program and the 39 routines that make up the standard XMP library.

To use the XMP library on your computer you must select one of the three standard versions: DEC, IBM, or CDC. These versions differ in the types of variable and array declarations that they use. These are:

DEC	Double precision Real Integer
IBM	Double precision Real Integer Integer*2
CDC	Real Integer

(For example, use the CDC version on a Burroughs computer, the DEC version on a UNIVAC computer.)

Copy the desired version of the routines in File 2, and then edit File 3 as follows.

DEC No editing is required

IBM Locate each of the 31 occurrences of the line:

> The next statement should specify half-words if possible.

Immediately following each of these lines is an integer declaration that should be changed to integer*2.
Note: You may use the DEC version on an IBM computer, but switching to integer*2 array declarations will save considerable main memory space for large problems.

CDC Make the following global substitutions:

From	To
Double precision	Real
DABS	ABS
D1	E1
LA05AD	LA05A
LA05BD	LA05B
LA05CD	LA05C

Note: The D1 to E1 substitution is for format codes. The double precision versions of the LA05 routines have a D appended to their names.

Directory of the Subroutines in the XMP Library.

Date last modified: June 8, 1981

There are six categories of subroutines in the XMP Library:

1) Subroutines that implement the logic of the simplex method.

2) Subroutines that serve as an interface between the simplex method and the data structure for the problem data.

3) Subroutines that serve as an interface between the simplex method and the data structure for the basis inverse representation.

4) Subroutines that manage the data structure for the problem data.

5) Subroutines that manage the data structure for the basis inverse representation.

6) Subroutines that provide miscellaneous support services.

Category 1. Subroutines that implement the logic of the simplex method.

XBCOMP	Computes the current values of the basic variables and the current value of the objective function.
XBREDU	Reduces the right-hand side to account for the non-basic variables which are at non-zero bounds.
XCAND	Constructs the candidate list. This is the list of attractive non-basic variables that are eligible to enter the basis during the subsequent series of minor iterations.
XCHECK	Checks the accuracy of the current primal and dual solutions.
XCHUZR	Determines the variable to leave the basis for a primal simplex pivot.
XDCHQ	Determines the variable to enter the basis for a dual simplex pivot.
XDCHR	Determines the variable to leave the basis for a dual simplex pivot.
XDOT	Computes the inner product between a row vector and a packed matrix column.
XDPH2	Executes phase 2 for the dual simplex method.
XDUAL	Top level routine for the dual simplex method.
XFEAS	Starts from any given basis and finds a primal feasible basis, if one exists. This routine is used as a phase 1 for the primal simplex method.

XPHAS2	Executes phase 2 of the primal simplex method.
XPIVOT	Pivots the chosen entering variable into the basis (primal simplex method).
XPRIML	Top level routine for the primal simplex method.
XPTIE	Resolves ties that arise during the ratio test for the primal simplex method (XCHUZR).
XSLACK	Sets up a starting basis with a slack variable for each less-than-or-equal constraint, a surplus variable for each greater-than-or-equal constraint, an artificial variable (with both bounds zero) for each equation, and a free variable for each free row. To be used with XPRIML (which calls XFEAS) or XDUAL.
XSTART	Used to start the primal or dual simplex method from any given basis.
XUPDX	Updates the primal solution and the objective function value.
XZCOMP	Computes the current value of the objective function.
FCAND	The fast version of XCAND: accesses the problem data structure directly.
FDCHQ	The fast version of XDCHQ: accesses the problem data structure directly.

Category 2. Subroutines that serve as an interface between the simplex method and the data structure for the problem data.

XADDAJ	Adds a single column to the existing linear program. (calls XDATA1)
XADDUB	Adds bounds for a single variable. (calls XDATA3)
XGETAJ	Gets a single column from the existing linear program. (calls XDATA2)

XGETUB	Gets the bounds for a single variable. (calls XDATA4)

Category 3. Subroutines that serve as an interface between the simplex method and the data structure for the basis inverse representation.

XBTRAN	Performs the "backward transformation," i.e., row vector * basis inverse. (calls LA05B)
XFACT	Re-factors (or re-inverts) the current basis. (calls LA05A)
XFTRAN	Performs the "forward transformation," i.e., basis inverse * column vector. (calls LA05B)
XUPDAT	Updates the current factorization (or inverse) of the basis. (calls LA05C)

Category 4. Subroutines that manage the data structure for the problem data.

XDATA1	Adds a single column to the problem data structure. (called by XADDAJ)
XDATA2	Retrieves a single column from the problem data structure. (called by XGETAJ)
XDATA3	Adds bounds for a single variable to the problem data structure. (called by XADDUB)

XDATA4	Retrieves the bounds for a single variable from the problem data structure. (called by XGETUB)

Category 5. Subroutines that manage the basis inverse representation.

Note: In this version of XMP the basis inverse is managed by the LA05 routines written by John K. Reid at Harwell.

LA05A	Factors the basis into L and U factors. (called by XFACT)
LA05B	Performs both the "backward transformation" and "forward transformation" operations. (called by XBTRAN and XFTRAN)
LA05C	Updates the factorization of the basis after a column exchange. (called by XUPDAT)
/LA05D/	A labelled common area for mumerical constants.
LA05E	A list compressor. (called by LA05A and LA05C)
MC20A	A sorting program. (called by LA05A)
XLA05X	An extra routine for interfacing the LA05A routine with XMP. (called by XFACT)

Category 6. Subroutines that provide miscellaneous support services.

XCONSA	Sets constants in the data structure for the problem data. (called by XMAPS)
XCONSI	Sets constants in the data structure for the basis inverse representation. (called by XMAPS)
XLOG	Prints log information after each pivot, if requested.
XMAPS	Sets up the map of the data structure for the problem data (MAPA) and the map of the data structure for the basis inverse representation (MAPI). Note: This must be the first XMP routine called by the user program.
/XMPCOM/	A labelled common area for numerical constants.
XPRINT	Prints the current basic solution and objective function value.
XSTOP	Provides for centralized handling of all fatal errors.

APPENDIX F

MOBILIZATION MENU STANDARDS AND SAMPLE MENU ADAPTATION*

In the event of full mobilization, it is assumed that a rapid troop build-up will occur within a relatively short timeframe. This short timeframe will necessitate local (installation) adjustment of the Master Menu, SB 10-260, to provide a menu capable of being prepared and served under the constraints of manpower, equipment, storage and kitchen facilities, etc., which will exist during mobilization. The adjusted menu will also provide a basis for requisitioning of subsistence by the Troop Issue Subsistence Activity.

Menus planned or adjusted within the framework of the Daily Food Guide (Basic 4 Food Groups) will assure a nutritionally adequate diet. The Basic 4 Food Groups and recommended daily servings are provided for information purposes:

1. Meat, poultry, fish or eggs, with dried beans, dried peas, nuts or peanut butter as alternates -- 2 or more servings daily.

2. Milk and milk products (includes ice cream and all types of cheese) -- 2 or more servings daily.

3. Vegetables and fruit -- 4 or more servings daily including a serving of citrus fruit (or juice) or other fruit/vegetable rich in Vitamin C and a dark green or deep yellow vegetable for Vitamin A.

4. Breads and cereals (enriched and whole grain) -- 4 servings daily.

The following menu standards have been developed to assist installation personnel responsible for adjusting the Master Menu, SB 10-260, for use during mobilization. These standards prescribed the minimum acceptable level of menus to be used. The service of short order meals is not required; however, such meals should be offered if sufficient manpower, equipment and facilities are available to do so. Also, the standards do not preclude programing choices of menu items in lieu of single selections if conditions permit.

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*Extracted from letter, DALO-TST, dated 7 May 1980, subject: Assessment of Mobilization Installation Capability to Provide Troop Support Services Under Full Mobilization.

MENU STANDARDS (MOBILIZATION)

I. GENERAL

A. All menus planned or adjusted should meet or exceed these standards.

B. Menu combinations offered at each meal will be planned to provide variety and contrast in texture, flavor and color.

II. BREAKFAST

A. At least one fruit, fruit juice or vegetable juice will be offered daily.

B. Ready-to-eat cereals will be offered daily; hot cereal or hominy grits will be offered at least once a week.

C. Eggs will be offered daily, as either "to order" or as a single method of preparation. If prepared as single method of preparation, the recipe will be varied from day to day to preclude monotony.

D. At least one breakfast meat will be offered daily.

E. Toast will be offered daily; a breakfast pastry or doughnut should be offered at least twice a week.

F. Butter or margarine, jam, jelly and peanut butter will be offered daily.

G. Milk, coffee and tea will be offered daily.

III. LUNCH AND DINNER

A. Soup will be offered at least three times a week at the lunch meal.

B. At least one entree will be offered at each lunch and dinner meal. Attention will be given to the spacing of menu entrees to avoid close repetition of similar items.

C. An appropriate sauce, gravy or garnish should be planned to accompany the entree.

D. A potato or potato substitute will be offered at each meal to complement the entree.

E. A cooked vegetable will be offered at each meal.

F. A salad will be offered at each meal. A raw, leafy green vegetable-type salad will be offered at least once a day.

G. A salad dressing, as appropriate to the specific salad, will be offered at each meal.

H. Bread or hot rolls or biscuits or cornbread will be offered at each meal together with butter and/or margarine.

I. A dessert item will be offered at each meal.

J. Milk, coffee and tea will be offered at each meal.

Table F-1. DA Master Menu (SB 10-260)

Breakfast	Lunch	Dinner
Chilled grapefruit segments	Minestrone soup (P-7)	Braised beef cubes (L-17)
Chilled orange juice	Garlic croutons (D-16)	Breaded veal cutlets (L-55)
A la carte menu	Sausage pizza (C-31)	Parsley buttered potatoes (Q-77)
Oven fried bacon (L-2)	Meat loaf (L-35)	Buttered broccoli (Q-G-3)
Grilled bologna	Mushroom gravy (O-16)	Buttered lima beans (Q-G-3)
Quick coffee cake (D-13)	Rissole potatoes (Q-52)	Spring salad (M-44)
Short order meal	French fried cauliflower (Q-20)	Vinaigrette dressing (M-71)
Minestrone soup (P-7)	Corn combo (Q-80)	Perfection salad (M-36)
Garlic croutons (D-16)	Garden vegetable salad (M-19)	Salad dressing
Standard short order meal	Celery seed dressing (M-52)	Cloverleaf rolls (D-33)
Baked ham sandwiches (N-11)	Mixed fruit salad (M-35)	Butter
Garden vegetable salad (M-19)	Creamy fruit dressing (M-56)	Apple crisp (J-1)
Celery seed dressing (M-52)	Assorted breads	Chocolate cream cake (G-32)
Mixed fruit salad (M-35)	Butter	Milk
Creamy fruit dressing (M-56)	Assorted ice cream	Tea
Assorted ice cream	Chocolate chip cookies (H-20)	Coffee (O-5)
Chocolate chip cookies (H-20)	Peanut butter cake (G-20)	Soft drinks
Peanut butter cake (G-20)	Peanut butter cream frosting (G-45)	
Peanut butter cream frosting (G-45)	Milk	
Milk	Tea	
Tea	Coffee (O-5)	
Coffee (O-5)	Soft drinks	
Soft drinks		

Table F-2. Sample Adjustment of DA Master Menu to Mobilization Menu Requirements

Breakfast	Lunch	Dinner
Chilled orange juice	Meat loaf (L-35)	Breaded veal cutlets (L-55)
Oven fried bacon (L-2)	Mushroom gravy (O-16)	Parsley buttered potatoes (Q-77)
Quick coffee cake (D-13)	Rissole potatoes (O-52)	Buttered lima beans (Q-G-3)
Scrambled eggs	Corn combo (Q-80)	Spring salad (M-44)
Toast	Mixed fruit salad (M-35)	Salad dressing
Butter	Creamy fruit dressing (M-56)	Cloverleaf rolls (D-33)
Assorted dry cereal	Assorted breads	Butter
Coffee (O-5)	Butter	Chocolate cream cake (G-32)
Milk	Assorted ice cream	Milk
	Chocolate chip cookies (H-20)	Tea
	Tea	
	Coffee (O-5)	

NOTE: In the sample adjustment shown, a typical day's menu from the DA Master menu has been adjusted to conform to the requirements of food service under mobilization. Among the adjustments shown are (1) deletion of the a la carte breakfast, (2) deletion of one breakfast meat item, (3) deletion of the short order lunch, (4) deletion of one lunch and dinner entree, (5) deletion of one lunch and dinner vegetable, (6) deletion of one lunch and dinner dessert, and (7) deletion of soft drinks. These adjustments are to be used as examples only. The mobilization menu should be as full as resources allow.

GLOSSARY

1. ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

ARCS	Army Ration Credit System
BDFA	basic daily food allowance
CAA	US Army Concepts Analysis Agency
DCSLOG	Deputy Chief of Staff for Logistics
EEA	essential elements of analysis
FMPS	Functional and Mathematical Programing System
FRIS	field rations issue system
GP	goal programing
LP	linear programing
MINOS	nonlinear programing system. Developed at Systems Optimization Laboratory, Stanford University
MIS	management information systems
RHS	righthand side. Refers to goals in the context of goal programing
SLGP	sequential linear goal programing
SPLP	sparse linear programing subprograms for solving linear programing problems. Developed at Sandia Labs
TISA	Troop Issue Subsistence Activity
TISO	Troop Issue Subsistence Officer
TSA	Troop Support Agency
XMP	library of subroutines for experimental math programing

2. TERMS UNIQUE TO THIS STUDY

acceptability	As applied to recipes, it is the percentage of persons who select a recipe when that recipe is placed on the serving line. As applied to menus, it is a computed factor by which menus of the same meal type may be compared for relative diner preference.
food cost	The dollar cost required to purchase the raw foods that comprise a recipe or menu.
labor cost	The number of manhours required to prepare a recipe or menu.
menu	A listing of the particular items to be served in a dining facility for a given meal.
nutrients	Those nutrients that are specified as being essential to a well-balanced diet. The 10 nutrients considered in this model are: calories, fats, protein, iron, Vitamin A, Vitamin C, thiamin, niacin, calcium, and riboflavin.
recipe	A ready to eat menu item which is the end result of a process of food preparation.

END

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